HELICOPTERS & AUTOGYROS OF THE WORLD

Paul Lambermont with Anthony Pirie

Enlarged and revised edition

Since its publication in 1957, M. Lambermont's *Helicopters and Autogyros of the World* has come to be regarded as an indispensable reference book in the aeronautical field. This standard work has now been revised so that a comprehensive and up-to-the-minute catalogue of world rotorcraft production, past and present, is available for the 1970's.

As in the previous edition, the products of many nations are included. Each country is given a separate section, each manufacturer his own sub-section and each machine (or project) a detailed entry, covering such aspects as its development, first flight, particular features and designations, followed by an exhaustive list of technical data. The book is prefaced by an historical survey of the development of the helicopter, from the small "Chinese top" developed by Launoy and Bienvenu in 1784 to the first flight of Cornu's machine in 1907. Also provided is a completely up-to-date list of recognized records and record-holders in the rotary-wing field, as well as official definitions of the various types of helicopter and autogyro.

Few men are better qualified to chronicle the achievements—and failures—of this ever-expanding industry than Paul Lambermont, former Press Attaché to the Fédération Aéronautique Internationale. Lavishly illustrated with photographs closely linked to the relevant text, *Helicopters and Autogyros of the World* is the most comprehensive and most detailed survey available within a single reference book.

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Paul Lambermont with
Anthony Pirie

Foreword by Igor I. Sikorsky

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(1) Distance in a straight line without landing
(2) Distance over a closed circuit
(3) Altitude
(4) Speed over a straight course
over a closed circuit
over a closed circuit with payload
(5) Time to climb to a given altitude
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(7) Endurance
(8) Women's records
(9) Convertiplane records
(10) Autogyro records

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Foreword to the First Edition

The last decade witnessed a number of extremely interesting and impressive achievements in flying. Among these we can cite the successful completion, in less than two days, of non-stop flights around the world, with refuelling in the air. Further, supersonic aeroplanes have carried men at more than 2,000 miles per hour and there are reasons to believe that this speed will be doubled around 1960 or so, and that within the next decade man will be flying over 100 miles above the surface of the earth and perhaps inaugurating space travel.

These and several other flights represent some of the most brilliant and spectacular achievements of human genius.

Much less spectacular, yet equally important and with at least as great a promise for the future, has been the development of the helicopter during this period. This modest newcomer to the family of flying craft started its career by saving tens of thousands of lives under conditions of war as well as in peacetime emergencies.

To mention only a few instances, over nine thousand two hundred lives were saved in the Mexican flood, several thousand during the floods in north-eastern United States late in 1955, scores in the Dutch flood, multitudes in the Haiti hurricane, and many thousands in various cases of individual emergencies.

The rescue of lives, no matter how important, must, nevertheless, be regarded only as a dramatic demonstration of what this aircraft can do due to its unique flight characteristics. It would be right to state that the helicopter is the most universal vehicle of transportation ever designed or used by man. When compared with any other means of travel, i.e., pack animal, wagon, automobile or railroad, we find the helicopter is completely independent of roads, bridges, swamps, snow, ice, or any other condition of the surface of the ground or water.

On the other hand, and in contrast with the aeroplane, the helicopter is in no need of an airport with its long, smooth runways, for departure or arrival. It can take off from or land on virtually any spot on earth.

As a load-carrier and again, in contrast with virtually any other vehicle, the helicopter is limited only by the weight of the object to be transported, but not by its bulk or length. This offers a completely new and virtually unlimited field of application for carrying huge objects, such as long sections of piping, small ready-made houses, small sections of a bridge, electric towers for power lines, and many others.

All the foregoing, together with the ability of the helicopter to reach

any point on land, in the wilderness, or in the heart of a big city—in fact, anywhere—makes it a truly outstanding vehicle of transportation which is destined to play a very important and growing role in our transportation system.

In view of the above, it has been a pleasant task for me to write these lines as a foreword to the work of Mr Lambermont which offers very interesting and much-needed information covering helicopter development from its beginning to the present time.

IGOR I. SIKORSKY
Bridgeport, Connecticut

14th January, 1958

Official Definitions

The following definitions are reproduced by special permission of the Fédération Aéronautique Internationale, universally known as F.A.I., from whose Sporting Code they are taken.

All rotary-wing aircraft are designated by the generic term 'Rotorcraft', defined as follows:

An aerodyne which, throughout or during part of its flight, derives the whole or a substantial part of its lift from a rotor system.

A rotor system is a set of external wings or blades arranged to rotate about a substantially vertical axis and thus provide lift for an aerodyne.

Rotorcraft are divided into four classes: Autogyro, Helicopter, Convertiplane, Vertoplane. The appropriate definitions are:

1. *Autogyro*
   A rotorcraft which, throughout or during part of its flight, derives the whole or a substantial part of its lift from an auto-rotating rotor system not provided with any form of direct power drive.

2. *Helicopter*
   A rotorcraft which, throughout its flight, derives substantially the whole of its lift from a power-driven rotor system whose axis (axes) is (are) fixed and substantially perpendicular to the longitudinal axis of the rotorcraft.

3. *Convertiplane*
   A rotorplane which, in vertical or hovering flight, derives substantially the whole of its lift from a power-driven rotor system whose axis (axes) is (are) substantially perpendicular to the longitudinal axis of the rotorcraft during such vertical or hovering flight, and in forward horizontal flight derives the whole or a substantial part of its lift from fixed wings.

4. *Vertoplane*
   A rotorplane capable: (*a*) of taking off and landing substantially vertically by virtue of lift derived from a power-driven rotor system whose axis (axes) is (are) fixed and substantially parallel with the longitudinal axis of the rotorcraft, and (*b*) of flying horizontally by virtue of lift derived from fixed wings when the longitudinal axis of the rotorcraft has been tilted over to a substantially horizontal attitude.

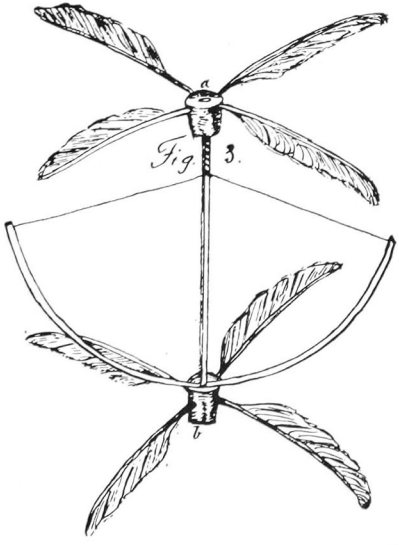
Historical Introduction

This brief historical survey will not cover the extremely long pre-history of rotary wings, nor even go back as far as the sketch of an aerial screw made by that universal genius Leonardo da Vinci at the end of the fifteenth century. It will deal solely with the most significant attempts made in this branch of aeronautics from the small 'Chinese top' device developed by Launoy and Bienvenu in 1784 to the first flight of Cornu's aircraft in 1907.

LAUNOY AND BIENVENU, 1784

A year after the first successful ascent by a hot-air balloon, Launoy, a naturalist, helped by a mechanic named Bienvenu, constructed a small device which seemed to have been inspired by the 'Chinese top' principle.

This scientific curiosity, consisting of two small propellers at the end of a shaft and with motive power coming from the tension of a bow bent through twisting its string around the shaft, was shown to the astonished members of the French Academy of Sciences in 1784.

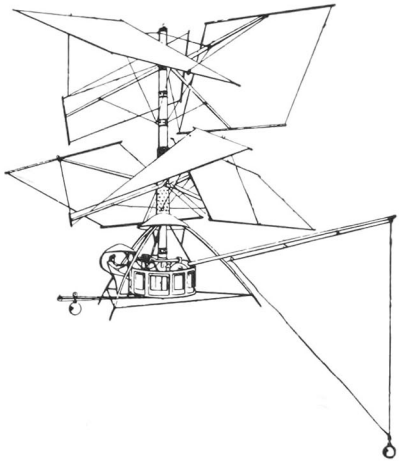


LAUNOY AND BIENVENU

SARTI, 1828

Surviving designs of the 'Aereo Veliero' (aerial sailing ship) by Vittorio Sarti, a Florentine cobbler settled in Bologna, were remarkable for the period.

The aircraft possessed two contra-rotating co-axial rotors, each formed, as it were, of three sails on to which were forced jets of steam issuing from a large number of nozzles cut into the mast.



SARTI

PHILLIPS, 1842

W. H. Phillips, inventor of the fire extinguisher, was also the first to have thought of a jet-propelled helicopter. The rotor was turned, somewhat in the manner of a lawn sprayer, by ejecting from the tips of the blades the gases produced from the combustion of a mixture of charcoal, nitre and gypsum. According to contemporary accounts, the aircraft, which weighed about 44 pounds (20 kilos), climbed rapidly to some height, crossed two fields and then a broken rotor put an end to the trials.

SIR GEORGE CAYLEY, 1843

In his twenty-third year, Sir George Cayley (1773–1857), later to be known as the 'Father of British Aeronautics', got wind of Launoy's and Bienvenu's experiments and set about making a model based on the same principles.

One of his published papers on 'Aerial Navigation' said of this heli-

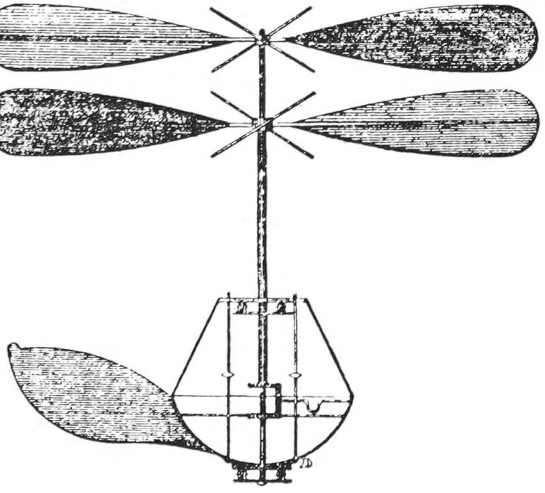
copter toy, made of a shaft of wood, feathers, cork, string and a whalebone bow, that 'for the purpose of ascent this is perhaps the best apparatus'.

But this investigator, with boundless curiosity, went still further. Though much of his energy was absorbed in managing the estates he had inherited, in politics, in philosophical speculations and in inventions such as, *inter alia*, the hot-air engine and the caterpillar tractor, his greatest passion was to discover a solution to the problem of flying by means of an airship, a glider or an 'ornithopter'.

One of his most remarkable 'insights' was described in the *Mechanic's Magazine* dated 8 April 1843. The 'Aerial Carriage' described there was presented as a convertible with contra-rotating rotors placed on each side of the body to be used for take-off and hovering, and with two pusher airscrews for horizontal flight. In Cayley's own words: 'The first may be termed the elevating fliers to distinguish them from the two smaller ones, set at a very different angle with their axis and used for propelling the machine when the others are stationary. Both sets will be put into action gradually, or in any degree by friction plates.' Several of the most recent designs, e.g. those of Focke-Wulf, Platt LePage and others, strongly recall Cayley's 'Aerial Carriage'.

BRIGHT, 1859

The first helicopter patent granted by the British Patent Office related to an aircraft with two contra-rotating co-axial two-bladed rotors mounted on a vertical shaft. The patentee was Henry Bright.

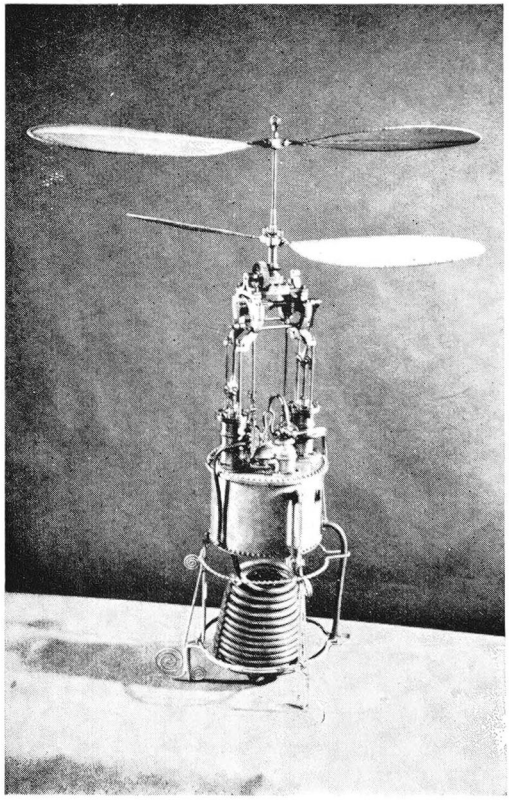


H. BRIGHT

This configuration has been adopted by numerous twentieth-century pioneers—Berliner, von Karman, von Asboth, D'Ascanio—and also by several recent manufacturers, including Bendix, Bréguet, Gyrodyne, Kamov, etc.

PONTON D'AMÉCOURT, 1862

Very shortly after Giffard successfully made a circular flight with his airship, Ponton d'Amécourt started his work on helicopters in the conviction that they were the only possible way to solve the problem of aerial navigation. He encountered the difficulty which, until the start of the twentieth century, baffled all workers with heavier-than-air machines: in Ponton d'Amécourt's time there was no engine light enough for flying.



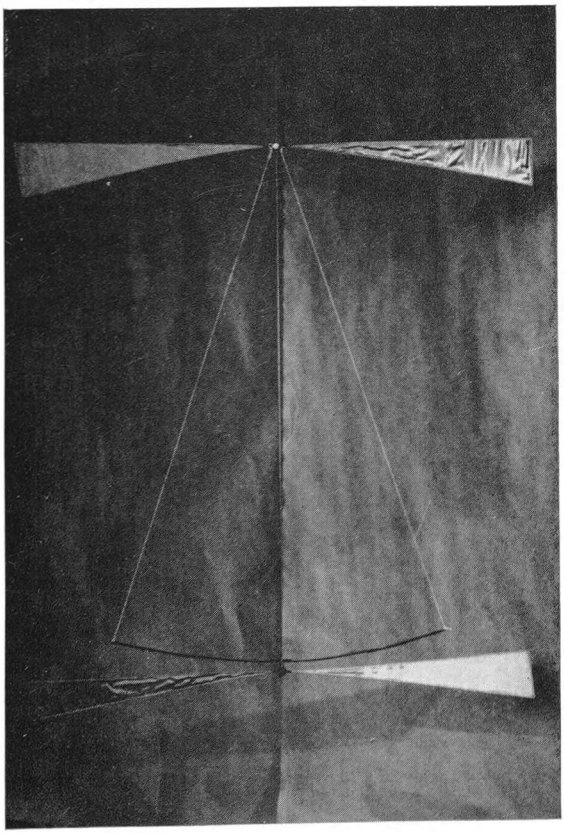
PONTON D'AMÉCOURT

Ponton d'Amécourt therefore built a small aluminium model driven by the steam from a coil-shaped boiler. This model with its two contra-rotating co-axial rotors is still preserved in the French Aeronautical Museum.

PENAUD, 1870

Shortly before his death at the age of thirty, Penaud revived a sort of 'Chinese top', with one original feature. Motive power was provided by pieces of twisted indiarubber—a method still in use today by aero modellers.

This aircraft had two contra-rotating rotors.



PENAUD

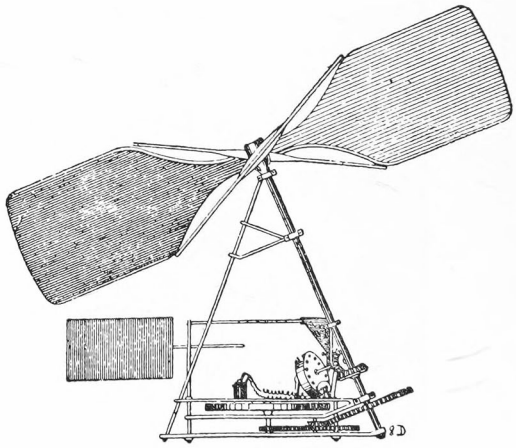
RYKACHEV, 1871

As early as 1860, M. A. Rykachev, a Russian, began investigating 'aerial propellers able to propel themselves horizontally and vertically'.

In 1871, after becoming Director of the Central Physical Laboratory, he conducted experiments concerned with the behaviour of, and the lift produced by, a small four-bladed rotor, which was made to turn through the combined effect of a falling weight and a clockwork spring placed on the pan of a balance.

POMÈS AND DE LA PAUZE, 1871

The model produced by these two French workers had a 'gunpowder engine', which may be regarded as the forerunner of modern rocket propulsion.



POMÈS AND DE LA PAUZE

ACHENBACH, 1874

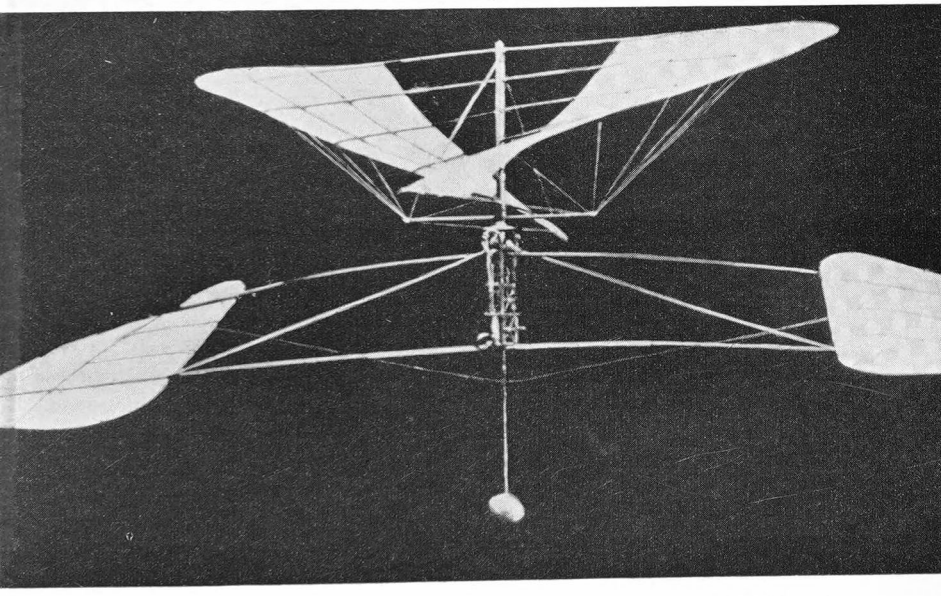
Achenbach, a German, designed an aircraft with a single rotor to ensure lift and also featuring a transverse airscrew to counteract torque.

FORLANINI, 1877

An Italian professor, Enrico Forlanini, had an ingenious idea for over-

coming the weight of a boiler and its firebox: shortly before his experiment started, he forced steam superheated to a pressure of about 142 pounds per square inch (10 kilos per square centimetre) into a small metal sphere, from which a calibrated valve allowed it to escape into the cylinders.

The complete assembly, including the two rotors, weighed hardly more than 8 pounds (3·6 kilos). It successfully became airborne, and in 1878 actually rose to a height of nearly 43 feet (13 metres), where it remained for some 20 seconds.

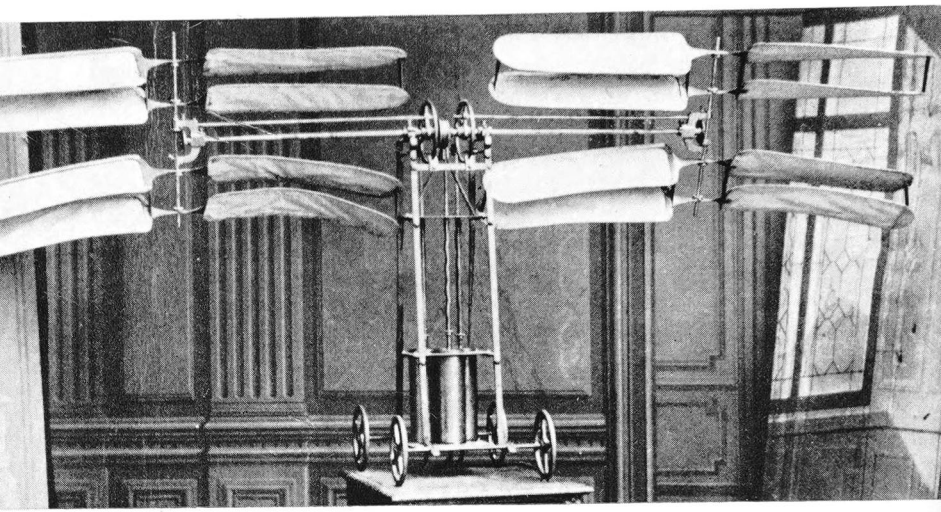


FORLANINI

CASTEL, 1877

In the same year as the Italian, Forlanini, Castel used a compressed-air engine to power two pairs of rotors, each with a diameter of 5 feet 7 inches (1·7 metres). The engine, incidentally, was fed by means of a flexible tube from a compressor on the ground. The aircraft's total weight was just over 50 pounds (22·7 kilos).

The device made a successful take-off, but crashed into a wall, which unlucky accident put an end to its career. Castel later had the idea of replacing his compressed-air engine by a petroleum engine.



CASTEL

MELIKOFF, 1879

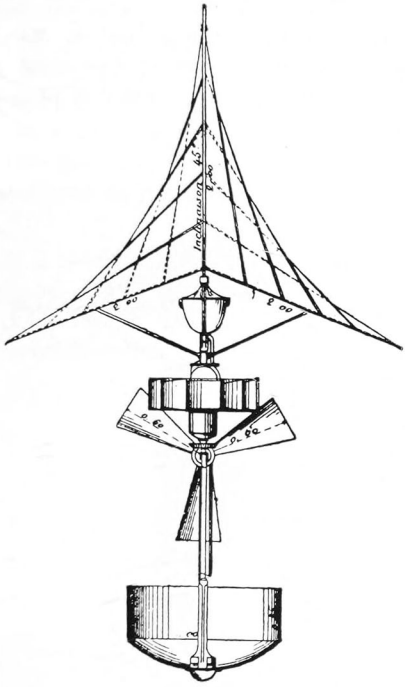
In 1879 Melikoff designed a model helicopter fitted with an airscrew having the shape of a double parabola to provide lift and also able to act as a parachute.

A three-bladed airscrew was to give the aircraft forward motion, and power was to be supplied by a turbine rotating under the action of a mixture of air and ether vapours.

EDISON, 1880

Thomas Edison, the famous American inventor, sometimes referred to as the 'Wizard of Menlo Park', also concerned himself with measuring the lift of rotors of various designs. The rotors were mounted on a vertical shaft driven at its lower end by an electric motor mounted on a platform scale. The latter was used to measure the lift developed. None of the various assemblies ever left the ground. Edison therefore concluded that no helicopter would be able to fly until engines had been produced with a weight of some 42–63 ounces (1,191–1,786 grams) per horse-power.

At a later date he stated his beliefs as follows: 'Whatever progress the airplane might make, the helicopter will come to be taken up by the advanced students of aeronautics.'



MELIKOFF

PARSONS, 1893

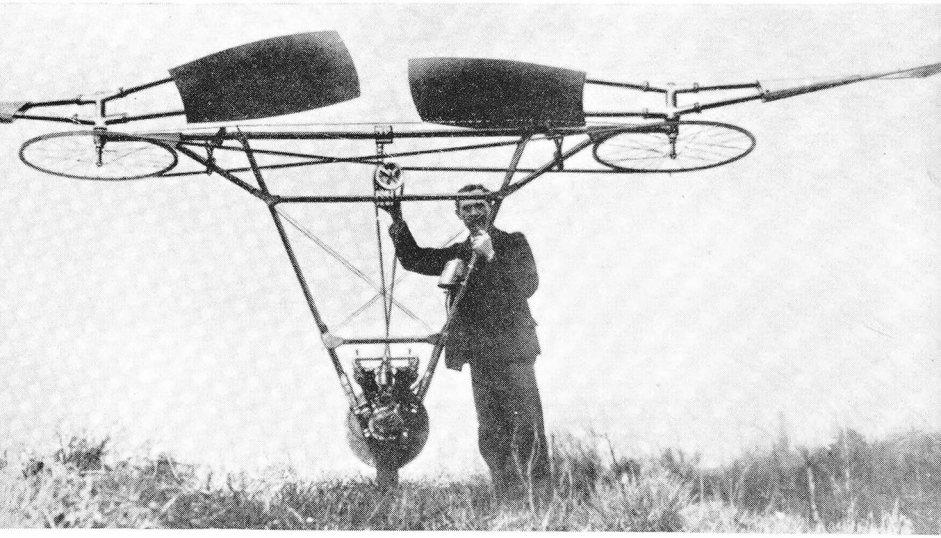
Sir Charles Parsons, an Englishman well known for his work on the steam turbine, built a model in which the single rotor was driven by a steam engine. Besides this rotor, the model had a fixed vertical fin.

The boiler operated at a pressure of 42·7 pounds per square inch (3 kilos per square centimetre), and produced $\frac{1}{4}$ h.p. at 1,200 revolutions per minute.

RENARD, 1904

In 1903–4, i.e. shortly before his death, Renard, a Frenchman, again aroused interest by a new aeronautical venture. As far back as 1884 he had distinguished himself by his work on dirigible balloons—in that year he made a balloon flight lasting 20 minutes and landed at his point of departure. His latest work was an aircraft propelled by two rotary wings set side-by-side and driven by a two-cylinder engine.

At about this time Renard wrote: 'To be complete, aircraft should have available practical means of take-off and landing, which only airscrews properly used to provide lift can ensure. It is probable that in the future this type of aircraft will offer the best method of navigating rapidly and in safety in the air.'



RENARD

CORNU, 1907

A French mechanic named Cornu, living in the Normandy town of Lisieux, first built a small model helicopter with two contra-rotating two-bladed rotors 7 feet 5 inches (2·26 metres) in diameter and driven by a Buchet 2 h.p. engine.

In October 1906 the model, which weighed 29 pounds (13 kilos), was attached to a merry-go-round at the end of an articulated arm, by which it could be lifted up and moved horizontally. This horizontal movement was obtained by means of adjustable wind-vanes placed in the rotors' slipstream.

Following these tests, Cornu built a full-size helicopter to the same design, roughly 20 feet 4 inches (6·2 metres) in length, and with two rotors also about 20 feet 4 inches in diameter at each end of a support with the shape of a widespread V. A 24 h.p. Antoinette engine placed just in front of the pilot's seat drove the rotors by means of belts.

On 13 November 1907 all the four wheels of this aircraft, which, including Cornu in the pilot's seat, weighed 573 pounds (260 kilos), simultaneously left the ground. The helicopter rose to a height of 1 foot (30 centimetres), and remained airborne for about 20 seconds. But this venture finally came to grief because of the frailness of the aircraft, the precariousness of the transmission system and, above all, lack of stability —a problem which Cornu had not even considered.

Australia

MOLYNEUX

The first attempt at rotary-wing construction in Australia was made by G. C. Molyneux, a consulting engineer of Melbourne, Victoria.

1956 XM-1000 (PROJECT)

This rotorcraft, developed from a small-scale experimental model, was designed to have two rotors set in tandem.

Engine: 500 h.p.
Rotor diameter: 30 ft (9·14 m)
Weight fully loaded: 4,000 lb (1,814 kg)
Cruising speed: 90 m.p.h. (145 k.p.h.)
Inclined climb: 970 ft/min (296 m/min)
Range: 350 miles (563 km)
Number of seats: 5

VICTA

In about 1959 Victa, a firm which manufacturers small engines, set up an aviation division. This division has since built a remarkable light airplane, the Airtourer, and also a gyroplane, for which John Blacker was responsible. Assistance was provided by Sydney University's Department of Aeronautics and various component manufacturers. The Victa aviation division closed down at the beginning of 1967.

1960 VICTA 67A

This autogyro has a two-bladed rotor, with a spin-up device for short take-offs. The blades are semi-rigid, and there is a pusher propeller aft. The machine has a tubular alloy structure, and it is equipped with twin tailplanes.

This autogyro, with a take-off run of 10 feet, first flew in 1962.

Engine: Lycoming, 180 h.p.
Length: (fuselage) 15 ft (4·57 m)
Height: 10 ft 5 in (3·18 m)
Rotor diameter: 27 ft (8·23 m)
Speed: (max.) 95 m.p.h. (153 k.p.h.)
Number of seats: 2

Austria

A number of patents for the theoretical application of jets to helicopters had been taken out prior to World War II, such as those by Ypma in 1923, Sikorsky in 1929, Dornier (Germany) in 1933, and in 1935 by Bleecker in the United States. Yet the first practical jet helicopter was not produced until Doblhoff completed his model in 1943, during the spring of which year it made successful flights in the suburbs of Vienna.

Doblhoff's idea has since been followed in various other countries, notably France, Great Britain and the United States of America.

BAUMGARTL

During World War II a young Viennese engineer named Paul Baumgartl designed various rotorcraft for individual use. After the war he emigrated to Brazil, where he continued his research work on rotary-wing aircraft at the Fabrica de Galeão, Rio de Janeiro.

1941 HELIOFLY I

This small two-bladed-rotor autogyro was attached to a parachute harness and was intended as a sporting glider. Its total weight was only 38 pounds (17 kilos).

1942 MODEL 57 (HELIOFLY III-57)

This helicopter also worked on the principle of attachment to a parachute harness; it had two co-axial contra-rotating single-bladed rotors.

Opposite to each blade about the axis of rotation was an engine acting as counterweight. Since the engines called for by the design could not be obtained, the project for this 'strap-on' helicopter had to be abandoned.
Engines (2)*:* Argus A.S. 8, 8 h.p.
Length: (overall) 15 ft 4 in (4·67 m)
Rotor radius: 7 ft 8 in (2·34 m)
Weight empty: 42 lb (19 kg)
Weight fully loaded: 240 lb (109 kg)
Number of seats: 1

1943 MODEL 59 (HELIOFLY III-59)

The same principle was applied to this as to the former model: two contra-rotating co-axial single-bladed rotors, but in the later version the

upper blade had a streamlined counterpoise instead of an engine. The upper blade thus had to be driven by a bevel gear from the engine mounted on the lower blade. Torque effects on the fuselage were avoided by this combined action.

The rotor head, with a 'spider' placed centrally, was similar to that used by Hafner on his Gyroplane.

The rotor system was mounted on a simple chassis to which two skids were attached.

Engine: 16 h.p.
Length: (overall) 20 ft (6·1 m)
Rotor radius: 10 ft (3·05 m)
Weight empty: 77 lb (35 kg)
Weight fully loaded: 265 lb (120 kg)
Number of seats: 1

For Baumgartl's later work, see under Brazil.

DOBLHOFF

From 1942 onwards Doblhoff began investigating the application of the jet principle to helicopters at the Wiener Neustädter Flugzeugwerke.

A conventional piston engine drove a compressor, in this particular case the supercharger blower of an Argus 411 engine. The mass flow of compressed air produced by this blower was mixed with fuel before passing through the hollow rotor blades to chrome steel combustion chambers situated at the blade tips. Combustion of this fuel-air mixture occurred at a rate of approximately 280 times per second.

Because of their very high consumption, these jets were used only for take-off, hovering and landing. In normal flight, the piston engine of the Doblhoff III and IV, which otherwise drove the compressor, was then clutched with an airscrew. When the jets were not working, the blades turned by auto-rotation and the aircraft behaved exactly like an autogyro.

Doblhoff designed the first helicopter in the world to take off by the use of jets.

After World War II, Doblhoff emigrated to the United States, where he collaborated in the development of the McDonnell compound helicopter. Of the other members of his team, Laufer went to France after the war and joined SNCASO, where he worked on the jet-propelled Djinn, and Stepan went to England, where he joined Fairey and also did work connected with jet-propelled rotary wings.

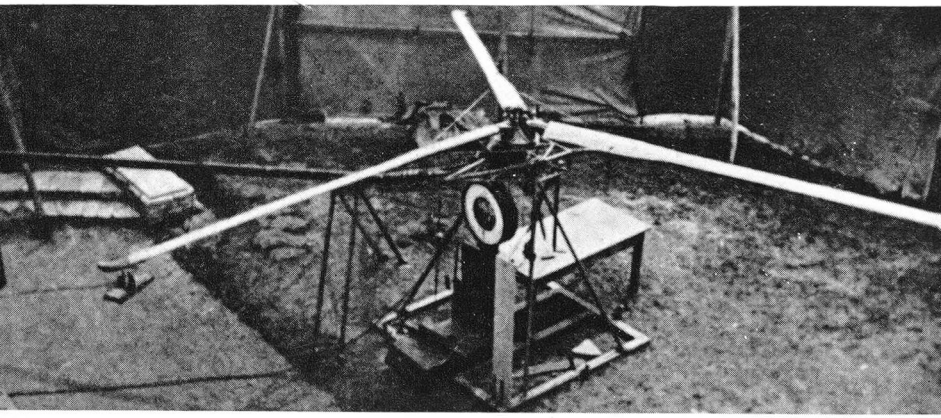
1943 DOBLHOFF I

Work was started by carrying out tests with hollow-bladed rotors

placed on top of a light-alloy scaffolding. A compressed-air tube entered the rotor hub, and vaporized petrol was added by special tubing. The mixture was ignited at the blade tip by an automobile sparking plug.

The effectiveness of the principle was dramatically proved: the rotor flew away with the attachment which held it on to the light-alloy scaffolding. Doblhoff then set about building his first prototype, which first flew in the spring of 1943. A 60 h.p. engine drove the compressor which supplied the compressed air, and the rotor was fitted with flapping and drag hinges.

Engine: 60 h.p.
Weight empty: 529 lb (240 kg)
Weight fully loaded: 794 lb (360 kg)
Number of seats: 1



DOBLHOFF I

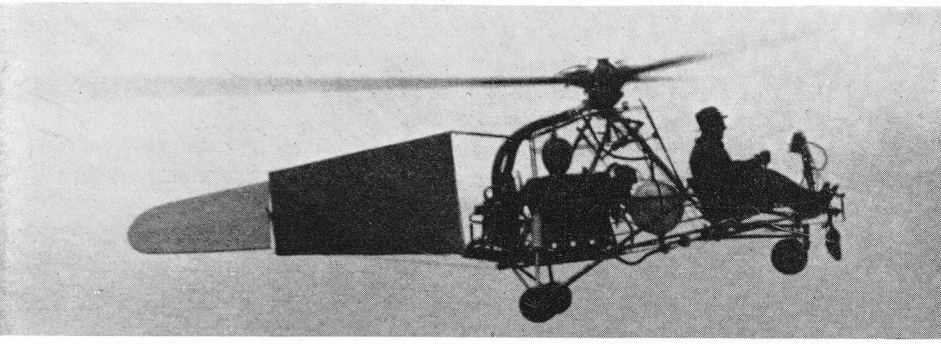
1944 DOBLHOFF II

The first version, which had been slightly damaged during an air raid on Vienna, was moved to Obergraffendorf, a place some 12 miles to the west, so that trials could proceed without interruption. A more powerful engine converted version I into version II.

Engine: 90 h.p.
Weight empty: 750 lb (340 kg)
Weight fully loaded: 1,014 lb (460 kg)
Number of seats: 1

1945 DOBLHOFF III

This cabin single-seater had the same jet-propulsion system as its pre-



DOBLHOFF II

decessors and also an airscrew which was brought into action for horizontal flight. The rotor turned at 305 r.p.m.

The rotorcraft was destroyed during its tests by the violence of its own oscillations.

Engine: 130 h.p.
Rotor diameter: 32 ft 5 in (9·88 m)
Weight fully loaded: 1,208 lb (548 kg)
Number of seats: 1

1945 DOBLHOFF IV

In this model, two leaf springs made of steel strips connected the blades to the hub and, as in the Doblhoff III, the engine performed two duties: either feeding compressed air via a compressor to the jet-propulsion system or driving an airscrew.

The Doblhoff IV had already logged 25 flying hours when Soviet troops were approaching the Austrian capital. The prototype was then hastily removed to Zell am See, where it was captured by American troops, who took it to the United States.

Engine: 135 h.p.
Rotor diameter: 32 ft 8 in (9·96 m)
Weight empty: 948 lb (430 kg)
Weight fully loaded: 1,411 lb (640 kg)
Number of seats: 2

NAGLER

In 1929, not far from Vienna, Bruno Nagler, in collaboration with Raoul Hafner, built his first helicopter, which was soon followed by others. All

these Nagler-Hafner helicopters were of the single-seater type, and though built in Austria were tested in the United Kingdom.

For a time Nagler flirted with autogyros and then during World War II designed a very unusual rotorcraft: a helicopter for individual use with a single blade and the engine as a counterweight.

During the war, in partnership with Rolz, he set up a company called Nagler-Rolz Flugzeugbau, which with help from the German Government built the first portable helicopter.

In 1952 Nagler emigrated to the U.S.A., where he continued to develop his original designs of helicopters with co-axial rotors for individual use.

1930 R-1 (REVOPLANE)

This first rotorcraft, made from welded tubes, had an engine situated forward and high up which drove the rotors with blades held in position by steel cables. Aft, there was a large surface consisting of sheeted wood and directly in the way of the rotor downwash.

The R-1 was taken to the United Kingdom, where it successfully hovered at very low altitudes on several occasions.

Engine: ABC Scorpion, 45 h.p.
Rotor diameter: 29 ft 6 in (9 m)
Number of seats: 1

1932 R-2

Designed, like its predecessor, in collaboration with Hafner, this rotorcraft had two thick elliptical wings aft. Variation in the incidence on these surfaces was produced in the vertical plane, i.e. in the plane of the stream of air created by the three-bladed rotor.

The fuselage was a lattice of welded steel tubes; the landing gear had two wheels and there was also a tail wheel.

This rotorcraft, too, made a certain number of short flights.

Engine: Salmson 9 Adr, 45 h.p.
Rotor diameter: 29 ft 6 in (9 m)
Number of seats: 1

1934 HELICOGYRO

This machine had a two-bladed rotor mounted on an oscillating plate. The engine, situated below and behind the rotor, drove a pusher propeller. The fuselage consisted of a lattice of metal tubes at the aft end of which there was a conventional tall structure; the upper longitudinal member of the lattice was in line with the axis of the airscrew.

The rotor could be driven by the engine, in which case torque was balanced by the stream of air from the airscrew upon the rudder; it could also revolve by auto-rotation, in the manner of an autogyro.

This model was also taken to the United Kingdom, where it was tested

by Nagler Helicogyro Ltd, a firm set up for the purpose. These trials took place in 1937.

Engine: Pobjoy, 90 h.p.
Number of seats: 1

1940 NAGLER-ROLZ NR-55

This aircraft had a single blade and an engine placed in such a way as to counterbalance the weight of the blade. At 9 feet 9 inches (2·97 metres) from the latter's centre of rotation was a set of two airscrews, 22½ inches (57 centimetres) in length and driven by shafting from the engine. The fuel tank and the carburettor system were placed above the central hub.

Hovering tests proved satisfactory but no horizontal flight tests were carried out.

Engine: 40 h.p.
Rotor diameter: 35 ft (10·67 m)
Weight fully loaded: 750 lb (340 kg)
Cruising speed: 60 m.p.h. (97 k.p.h.)
Number of seats: 1

1941 NAGLER-ROLZ NR-54V-1

Similar to the former, except for lower range, less powerful engine, and smaller rotor diameter.

Engine: 24 h.p.
Rotor diameter: 26 ft (7·92 m)
Weight empty: 176 lb (80 kg)
Weight fully loaded: 390 lb (177 kg)
Cruising speed: 55 m.p.h. (89 k.p.h.)
Number of seats: 1

1941 NAGLER-ROLZ NR-54V-2

The rotor consisted of two blades, each carrying a small 8 h.p. engine weighing 10 pounds (4·5 kilos), set at a radius of one-third the rotor length when measured from the centre of the hub.

This helicopter was portable, and the framework consisted of a metal assembly of three beams each terminating in a low-pressure wheel. The pilot sat on a very primitive seat and the controls consisted of two levers, one to regulate blade pitch, the other to control the two engines.

In all, four of these rotorcraft were built by the Nagler-Rolz Flugzeugbau.

Engines (2)*:* Argus A.S. 8 (i.e. 16 h.p. in all)
Rotor diameter: 26 ft (7·92 m)
Weight empty: 80 lb (36 kg)
Weight fully loaded: 310 lb (140 kg)
Cruising speed: 50 m.p.h. (80 k.p.h.)

Inclined climb: 500 ft/min (152 m/min)
Absolute ceiling: 1,500 ft (457 m)
Range: 30 miles (48 km)
Number of seats: 1

For Nagler's subsequent work, see under United States of America.

Belgium

FLORINE

The first tandem-rotor helicopter to achieve sustained flight was made by this Russian-born engineer for the Service Technique de l'Aéronautique Belge (Belgian Aeronautical Technical Service).

The two four-bladed rotors, placed one at each end of a tubular metal fuselage, were driven by a Hispano-Suiza 180 h.p. engine. The aircraft, which had a long period of teething troubles and was finally damaged during static trials, was the outcome of investigations which Florine had been engaged on since 1927 at the Belgian Aeronautical Laboratory at Rhode-St-Germain.

With a grant from the Belgian National Fund for Scientific Research, Florine built a second and lighter version (weight in flying condition 2,094 pounds [950 kilos]) with a more powerful engine, a fan-cooled Renard 200 h.p. unit. The four-bladed rotors, 23 feet 6½ inches (7·2 metres) in diameter, turned in the same direction and their axes were inclined to counteract torque. Stability and control were obtained by varying the pitch of the blades.

This helicopter began flying in April 1933 and on 25 October of that year it successfully rose 16–19 feet (5–6 metres) from the ground, and remained airborne for 8 minutes 40 seconds.

VILLARD

In 1913 Henry Villard, who had previously performed some direct-lift experiments in France, carried out various trials in a balloon hangar near Brussels with an aircraft which he had designed. It was a lifting device 8 feet 10¼ inches (2·7 metres) in diameter, driven directly by a 100 h.p. 1912-type Anzani engine. The device weighed 882 pounds (400 kilos), and during its tests the rear wheels left the ground.

Early in 1914 Villard built a second model with a frame made of steel tubes. An Anzani 100 h.p. radial engine was mounted on top of a central tripod structure to which the rotor blades were attached. Movements of the pilot's seat enabled the aircraft's centre of gravity to be shifted. There was also a small tail rotor 1 foot 11¾ inches (60 centimetres) in diameter.

Villard's tests were brought to a swift end by the German invasion of Belgium.

Brazil

From the historical angle much interest attaches to a project by the great Brazilian aeronautical pioneer, Alberto Santos-Dumont. In 1906 he designed a helicopter with two lifting airscrews, 19 feet $8\frac{1}{4}$ inches (6 metres) in diameter, and made of bamboo covered with silk. They were placed at the ends of a vertical frame set above the platform which was to take the engine and the pilot.

Steering was to be governed by a tail rudder similar to that used on fixed-wing aircraft. In horizontal flight, Santos-Dumont planned a traction airscrew forward, so that the aircraft was more a 'compound' than a pure helicopter.

When the Levasseur 24 h.p. Antoinette engine failed to lift the aircraft, Santos-Dumont abandoned the project and devoted himself exclusively to fixed-wing aircraft.

Some forty years were to elapse before helicopters designed in Brazil again began to be made there, after the end of World War II.

BAUMGARTL

At the end of World War II, during which he had conceived various Heliofly models of original design in Austria (see under Austria), Paul Baumgartl emigrated to Brazil.

There he continued his work on rotary wings within the framework of the Fabrica de Galeão, an aircraft factory owned by the Brazilian Government.

This factory, the origin of which goes back to the 1937–9 period, passed into the control of the Brazilian Ministry of Aviation when the latter was first set up early in 1941, and has since been engaged in manufacturing aircraft under licence. Thus, for instance, following an agreement with the Netherlands Aircraft Company, it was made responsible for the output of Fokker trainers.

Baumgartl's prototypes, which were somewhat of an experimental venture in this factory, are now the property of the Brazilian Government.

1949 PB-61

This single-seater helicopter had co-axial contra-rotating two-bladed rotors. The rotor head had a swash plate between the two hubs to control collective pitch, while a second swash plate, directly connected to the

stick, and situated beneath the lower rotor, controlled cyclic pitch. The swash plates were connected by push-pull rods. Flapping hinges were provided, but drag hinges were not, since the hubs were of the tilting type.

The fuselage was a welded chrome molybdenum steel structure, and there was a tripod landing gear. Behind the pilot was the 4-cylinder engine in a horizontal position with a vertical crankshaft.

During its ground and flight trials numerous changes were made in this helicopter. The diameter of both rotors was increased, the distance between the rotor hubs was extended, and yaw control by rotor brakes was replaced by a fin placed in the rotor's slipstream.

Tests started in 1950.

Engine: Continental O-170-3, 65 h.p.
Length: (fuselage) 8 ft 10 in (2·69 m)
Height: 10 ft 2 in (3·1 m)
Rotor diameter: (upper) 21 ft (6·4 m)
(lower) 24 ft 6 in (7·47 m)
Weight empty: 542 lb (246 kg)
Weight fully loaded: 835 lb (379 kg)
Number of seats: 1

1953 PB-63

This single-seater was developed from the PB-61, but it no longer kept to the co-axial configuration, possessing instead a two-bladed teetering-type rotor, in which cyclic and collective pitch changes were obtained by a single swash plate. The tail rotor, rotation of which was obtained through a transmission consisting of a single vee belt, was a single blade constructed from light wood and with a stainless steel leading edge.

The fuselage and landing gear were the same as those in the PB-61.

Engine: Continental C-85-12, 85 h.p.
Rotor diameter: 19 ft 8¼ in (6 m)
Weight empty: 525 lb (238 kg)
Weight fully loaded: 794 lb (360 kg)
Inclined climb: 1,400 ft/min (427 m/min)
Absolute ceiling: 7,500 ft (2,286 m)
Number of seats: 1

1957 PB-64

This simplified ultra-light single-seated helicopter is powered by two pulse-jet engines mounted on the tip of a long stabilizing bar set at 90 degrees to the two-bladed rotor.

Engines (2)*:* JTA
Length: 15 ft 0½ in (4·58 m)
Height: 7 ft 6½ in (2·3 m)
Rotor diameter: 21 ft (6·4 m)

Weight empty: 238 lb (108 kg)
Weight fully loaded: 507 lb (230 kg)
Number of seats: 1

BEIJA-FLOR

This helicopter (the Portuguese name means 'humming bird'), inspired by the work of the German expert, Professor Focke, was built at the Centro Tecnico de Aeronautica at São José dos Campos in the State of São Paulo. This technical centre is part of the research and development branch of the Brazilian Government's Ministry of Aviation.

1956 BF-1

This two-seater helicopter has one main three-bladed rotor and two anti-torque rotors carried on short supports aft.

It was specially designed as a general light-utility helicopter, particularly suited to Brazil's present-day transportation needs and state of industrial development. The design has been simplified to reduce cost, to avoid the need for any highly specialized or unusual manufacturing processes, and to facilitate maintenance, while providing outstanding control and flight stability.

Final flight tests took place about the middle of 1957.
Engine: Continental E-225-8, 225 h.p.
Rotor diameter: 29 ft 6 in (9 m)
Weight empty: 1,477 lb (670 kg)
Weight fully loaded: 1,918 lb (870 kg)
Cruising speed: 87 m.p.h. (140 k.p.h.)
Range: 1 hour (endurance)
Number of seats: 2

Canada

AVIAN

Avian Aircraft Limited set about building an autogyro designed by a small group of former Avro engineers. Development proceeded slowly, not because of technical but because of financial difficulties. The latter were finally overcome in 1964 by a Government grant intended to speed up the development of this light rotorcraft.

1959 AVIAN 2-180 GYROPLANE

The first prototype built by Avian Aircraft was an autogyro with a blade-tip drive system powered by compressed air from a bottle re-loaded automatically in flight so as to make jump take-off possible.

The second prototype, of more conventional design, did not incorporate this system. The final version, of similar appearance, has a light-alloy structure and a tricycle undercarriage with a castoring nose wheel. The fuel tank is located behind the cabin with two seats in tandem at the actual centre of gravity. The three-bladed rotor is controlled by a conventional cyclic pitch system and can be started through a shaft for take-off. The ducted propeller is housed aft.

The minimum forward speed is about 30 m.p.h. (48 k.p.h.).
Engine: Lycoming IO-360, 200 h.p.
Length: (fuselage) 17 ft (5·18 m)
Width: 8 ft (2·44 m)
Height: 9 ft 7 in (2·92 m)
Rotor diameter: 37 ft (11·28 m)
Weight empty: 1,300 lb (590 kg)
Weight fully loaded: 1,900 lb (862 kg)
Cruising speed: 100 m.p.h. (161 k.p.h.)
max: 120 m.p.h. (193 k.p.h.)
Inclined climb: 870 ft/min (265 m/min)
Range: 400 miles (644 km)
Number of seats: 2

DOMAN-FLEET

The Fleet Manufacturing Ltd is a Canadian company founded in 1930 and latterly engaged in manufacturing radar equipment as well as pro-

ducing major components for the F-86 Sabre and landing-gear assemblies for the F-84. In 1953 it entered into an agreement with Doman Helicopters, Danbury, U.S.A., to set up a jointly owned Canadian subsidiary, Doman-Fleet Helicopters, to market the Doman eight-seater LZ-5 in the Dominion. In 1955 the Fleet factories started producing the LZ-5.

For technical features, see Doman LZ-5 under United States of America.

1956 PROJECT

Doman-Fleet has also done development work on a projected transport helicopter capable of carrying 20 passengers in a special cabin.

Power is to be supplied by three General Electric T58 turbines.

INTERCITY AIRLINES

Bernard Sznycer was born in Poland and worked there till shortly before the invasion of that country which heralded World War II. In particular he designed for the pre-war Polish national airline LOT a ski-wheel combination which was later used on some military aircraft.

He spent the war years in the U.S.A., and while there produced for W. Frazier, president of the Pitcairn-Larsen Autogiro Company, a glider known as 'Prelude'. It was about this time that Sznycer's interest in helicopters started.

Early in 1944 Sznycer, in partnership with Miss Selma Gottlieb, set up a small consulting engineering business, which in 1945 signed a contract with the Intercity Airlines Company of Montreal to design a helicopter specially suited for 'bush country' conditions and climate.

On 9 July 1947 the first Canadian helicopter, Sznycer and Gottlieb's SG Mark VI, made its trial flight. This experimental aircraft was followed by several variants, one of which was fitted with devices of special value to agriculture.

1947 SG-VI

The main rotor of this aircraft has four flapping blades made of plastic material with a stainless steel leading edge. The 5-foot (1·52-metre) tail rotor also has four blades. The auto-rotation clutch is at the rotor hub, which thus avoids all difficulties in the event of transmission or engine failure.

One outstanding feature is the ease of servicing and maintenance. The engine, for instance, is placed horizontally so that it can be taken out in five minutes. Another feature is ability to stand up to cold weather: most of the trials were carried out at nearly freezing temperatures.

Engine: Franklin 6A4-165-B6F, 178 h.p.

Length: 32 ft (9·75 m)
Width: (wheelbase) 11 ft 10 in (3·61 m)
Height: 9 ft (2·74 m)
Rotor diameter: 35 ft (10·67 m)
Weight empty: 1,700 lb (771 kg)
Weight fully loaded: 2,400 lb (1,090 kg)
Cruising speed: 75 m.p.h. (121 k.p.h.)
Inclined climb: 1,000 ft/min (305 m/min)
Range: 200 miles (322 km)
Number of seats: 3

PIDEK

Joseph Pidek, a former pilot in the Polish Air Force, has built in Vancouver a light two-seater helicopter. Its ground testing started in 1962.

1962 JP-2B

This home-built conventional helicopter is powered by two engines mounted externally on each side of the fuselage. The main rotor has three blades of laminated wood covered with fibreglass. The tail rotor is two-bladed.

Engines (2)*:* Ariel, 50 h.p. each
Height: 7 ft (2·13 m)
Rotor diameter: 22 ft 10 in (6·96 m)
Weight empty: 720 lb (327 kg)
Cruising speed: 90 m.p.h. (145 k.p.h.)
Inclined climb: 1,000 ft/min (305 m/min)
Number of seats: 2

China (Nationalist)

C. J. CHU

Though the helicopter principle, as is shown by the Chinese top, has been known in China for centuries, the first true Chinese helicopter goes back only as far as 1945. It was produced by Major-General Chu.

C. J. Chu studied aviation technology in the U.S.A., returned to China and was for thirteen years director of an aircraft manufacturing plant at Yunnan, which built various American aircraft and also the Soviet I-15 under licence.

1945 HUMMING BIRD A

In 1945 C. J. Chu turned his attention to rotorcraft and designed a co-axial helicopter, known as the Humming Bird Model A. During the tie-down test, the ground screw came off with the rope, the Humming Bird tipped over and both its rotors were broken.

A start was immediately made on building a second version, the Humming Bird Model B. But, as the general laconically tells the story: 'Just as it was finished, however, I was sent to Formosa and for a variety of reasons we had to leave the ship on the mainland. . . .'

HUMMING BIRD A

1948 HUMMING BIRD B

This was a single-seater, co-axial helicopter, which was abandoned on the mainland when the Chinese Nationalist Government evacuated to the island of Formosa.

Engine: Kinner B-5, 125 h.p.
Width: 7 ft 8 in (2·34 m)
Height: 8 ft 7½ in (2·63 m)
Rotor diameter: 25 ft (7·62 m)
Weight empty: 1,300 lb (590 kg)
Weight fully loaded: 1,600 lb (726 kg)
Cruising speed: 70 m.p.h. (113 k.p.h.)
max: 85 m.p.h. (137 k.p.h.)
Inclined climb: 460 ft/min (140 m/min)
Hovering ceiling: 3,000 ft (914 m)
Range: 132 miles (212 km)
Number of seats: 1

While in Formosa, Chu became interested in the tandem configuration and set to work again. After eighteen months' work, the aircraft was ready.

HUMMING BIRD B

1952 CJC-3

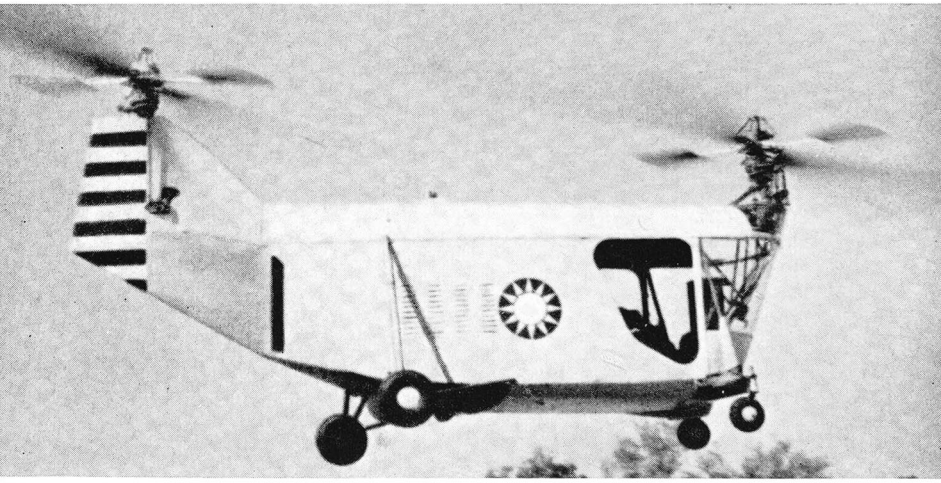
This dual-control two-seater aircraft is of chrome steel construction. The two-bladed see-saw-type rotors, set in a tandem overlapping position, both have stabilizing bars at right angles to the blades.

The engine is placed amidships and its power passes through a main transmission box branching out to the front and rear rotors through two small gearboxes.

The landing gear consists of four wheels.

Engine: Lycoming, 190 h.p.

Rotor diameter: 24 ft 6 in (7·47 m)
Weight empty: 1,500 lb (680 kg)
Weight fully loaded: 2,050 lb (930 kg)
Cruising speed: 85 m.p.h. (137 k.p.h.)
max: 112 m.p.h. (180 k.p.h.)
Inclined climb: 1,530 ft/min (466 m/min)
Ceiling: 12,000 ft (3,658 m)
Range: 135 miles (217 km)
Number of seats: 2



CJC-3

Colombia

SALDARRIAGA, 1953

This was the first helicopter to be built in the Republic of Colombia, and was a home-made model constructed by a citizen of Medellín named Antonio Saldarriaga. It was a two-seater fitted with a two-bladed main rotor and also with a two-bladed tail rotor.

Engine: 125 h.p.
Rotor diameter: 27 ft (8·23 m)
Number of seats: 2

Czechoslovakia

During the inter-war period the Czech aeronautical industry reached a high level of achievement, particularly in the fields of light aircraft and engines.

That industry, apart from the Aero factories at Prague, which were heavily bombed by the Allies, emerged from World War II virtually undamaged. In the autumn of 1945 the industry was nationalized, and at a later date all factories producing aircraft and motor-vehicles were formed into a State consortium known as Czechoslavenska Zovody Automobilove A Letecke, Narodni Podnick.

As regards rotary-wing aircraft, the first step was the reconstruction from spare parts of the German Fa-223 or Drache, soon to be followed by development work on a wholly Czech design, such as the XE-1 (Project), HC-2 and HC-3.

XE-1, 1947

A model of this project worked out at Karlin was exhibited at Brussels in July 1947. It had two intermeshing two-bladed rotors, the hubs of which were very close together.

Also provided was a tricycle landing gear with the rear wheels directly below the twin vertical fins.

Engine: Praga M-197, 100 h.p.
Number of seats: 2

XE-11, 1949

This was the first full-scale experimental helicopter to be tried out in 1950 as a test for the rotor system, drive and controls. It took the form of a standard helicopter equipped with a three-bladed rotor.

Engine: Praga D, 75 h.p.
Length: (overall) 34 ft 5½ in (10·5 m)
Rotor diameter: 28 ft 10½ in (8·8 m)
Weight empty: 705 lb (320 kg)
Weight fully loaded: 993 lb (450 kg)
Cruising speed: 65 m.p.h. (105 k.p.h.)
max: 75 m.p.h. (120 k.p.h.)

Inclined climb: 591 ft/min (180 m/min)
Ceiling: 8,202 ft (2,500 m)
Number of seats: 1

HC-2 HELI-BABY, 1953

This helicopter, designed by an engineer named Jaroslav Slechta, who was also engaged on the XE-1 project, has a three-bladed main rotor, and a two-bladed tail rotor. Power for the tail rotor is transmitted by an oblique exposed shaft of the type found in the American Hiller helicopters.

The light-alloy cabin can seat two persons side-by-side; the rotor control is the handlebar overhead lick-stick type. There is also a tricycle undercarriage.

HC-2

This light helicopter was designed to carry out various kinds of duties, such as mail services, observation flights, training, etc. On 27 June 1959 it set up an international record for speed over a closed 100 kilometre circuit in Class E1 (for helicopters weighing less than 500 kilos). It flew at a speed of 182 k.p.h. with an average of 120 k.p.h.

A more powerful version of the HC-2, in which the Praga 80 h.p. DH engine was replaced by an M110H with an output of 110 h.p., was mass-produced under the designation of HC-102.

Engine: Praga DH, 80 h.p.
Length: 23 ft 9⅜ in (7·25 m)
Rotor diameter: 28 ft 10½ in (8·8 m)
Weight empty: 816 lb (370 kg)

Weight fully loaded: 1,279 lb (580 kg)
Cruising speed: 62 m.p.h. (100 k.p.h.)
Inclined climb: 558 ft/min (170 m/min)
Ceiling: 10,000 ft (3,048 m)
Range: 93 miles (150 km)
Number of seats: 2

HC-3, 1959

This general-purpose three-bladed-rotor helicopter is larger than the HC-2. With its all-metal semi-monocoque-structure fuselage it can carry either three or five persons on seats or a payload when the seats are removed. The undercarriage landing gear consists of four wheels.

Engine: M108H, 240 h.p.
Length: 32 ft 10 in (10 m)
Height: 11 ft $3\frac{7}{8}$ in (3·45 m)
Rotor diameter: 38 ft $0\frac{3}{4}$ in (11·6 m)
Weight empty: 1,984 lb (900 kg)
Weight fully loaded: 2,998 lb (1,360 kg)
Cruising speed: 100 m.p.h. (161 k.p.h.)
Service ceiling: 13,780 ft (4,200 m)
Range: 193 miles (310 km)
Number of seats: 3–5

Z-35, 1960

This small helicopter with two side-by-side seats is of conventional design. It has one three-bladed main rotor and a tail rotor at the end of a beam consisting of a tubular structure. The landing gear consists of two skids with two small retractable wheels.

Engine: Walter M332, 140 h.p.
Length: 26 ft $11\frac{1}{2}$ in (8·22 m)
Height: 8 ft $5\frac{1}{2}$ in (2·58 m)
Rotor diameter: 28 ft $10\frac{1}{2}$ in (8·8 m)
Weight empty: 1,025 lb (465 kg)
Weight fully loaded: 1,598 lb (725 kg)
Cruising speed: 68 m.p.h. (110 k.p.h.)
max: 81 m.p.h. (130 k.p.h.)
Ceiling: 12,630 ft (3,850 m)
Range: 155 miles (250 km)
Number of seats: 2

ZAVODI Fa-223, 1947

Two helicopters in every respect identical with the German Focke-Achgelis 223 (*q.v.*) were built from salvaged spare parts.

In France, too, the Fa-223 was reconstituted under the supervision of Professor Focke, and was given the designation SE-3000 (see under France; SNCASE SE-3000).

Engine: Bramo, 1,000 h.p.
Length: (overall) 40 ft $2\frac{1}{2}$ in (12·26 m)
Rotor diameter: 39 ft $4\frac{1}{8}$ in (12 m)
Weight fully loaded: 9,502 lb (4,310 kg)
Cruising speed: 75 m.p.h. (121 k.p.h.)
Inclined climb: 720 ft/min (219 m/min)
Absolute ceiling: 16,000 ft (4,877 m)
Range: 200 miles (322 km)
Number of seats: 4

Denmark

Prior to World War I, the only attempt made at rotary-wing flight in the Scandinavian countries was by the Danish pilot Ellehamer, a well-known aeronautical figure at the time.

His helicopter, trials of which were held at Copenhagen in 1912, was of a rather unusual type. It included two co-axial rotors, each forming a circle 19 feet 7 inches (5·97 metres) in diameter and surrounded by six small blades, the pitch of which could be set as the pilot wished. The lower circle was fabric-covered. These rotors were driven by an engine with six cylinders, mounted radially, and built by Ellehamer himself.

The aircraft actually succeeded in rising a few inches off the ground.

France

B.D.M.

B.D.M. are the initials of three helicopter technicians who in 1960 and 1961 jointly produced a small experimental rotorcraft: André Bruel, who had been an engineer in the Nord Aviation helicopter department, and his collaborators Duhamel and Molinari. The helicopter was tested at the Saint-Cyr airfield and is now in the French Air Museum.

1961 B.D.M. 01

This small single-seater has the following features: a two-bladed rotor with a tilting hub, an engine using belts and pulleys to drive a motor-vehicle-type reduction gearbox with bevelled gears, and a tail rotor embodying an unusual idea. The fixed-pitch tail rotor is unique in that its vertical rotational plane can be altered by turning the whole unit. Thus in hovering flight its thrust can be directed laterally to counteract torque from the main rotor, while in cruising flight the thrust is directed aft to aid propulsion.

Engine: 65 h.p.
Rotor diameter: 24 ft $1\frac{3}{8}$ in (7·35 m)
Weight empty: 595 lb (270 kg)
Weight fully loaded: 816 lb (370 kg)
Number of seats: 1

BRÉGUET

At the very time when the Wright Brothers were making their historic flight, Louis Bréguet's attention was turning towards the helicopter. In collaboration with Professor Richet he set about building his first rotorcraft, known as Gyroplane No. 1. In 1907 this model actually flew, but certain difficulties were encountered. It was followed in 1908 and 1909 respectively by Gyroplane No. 2 and the Bréguet-Richet No. 2 *bis*. Work on these aircraft convinced Bréguet that the power-weight ratio in available engines was too low, and the absence of high-strength light metals persuaded him to abandon rotorcraft in favour of fixed-wing aircraft.

These Bréguet began manufacturing in 1909, and by the end of World War I he was one of the world's major constructors. Some 8,000 Bréguet 14s were built. In 1926 one of the Bréguet 19s set up a world long-

distance record of 3,473 miles (5,396 kilometres). In 1930, yet another of these Bréguet 19s made the first direct Paris–New York flight.

In 1935 Bréguet returned to the helicopter field with his Laboratory Gyroplane which late in 1936 broke all the world records for aircraft of that type. This Laboratory Gyroplane embodied the various patents taken out by Bréguet in 1929 and 1930 regarding the 'stabilization of rotary-wing aircraft'.

It should be added that shortly before his death in 1956 Bréguet was working on an aircraft with a turbine-lift wing. It had wings in the centre of which were two small-diameter rotors, with peripheral paddles driven by the flow taken off the main turbines.

1907 GYROPLANE NO. 1

This Gyroplane No. 1 was built at Bréguet's aircraft workshops at Douai. Its engine, a 45 h.p. Antoinette, operated four rotary wings 26 feet 3 inches (8 metres) in diameter.

Weighing 1,274 lb (578 kilos) with its pilot aboard, the helicopter on several occasions rose about 5 feet (1·5 metres) from the ground, but since it proved rather unmanageable in horizontal flight, it had to be steered by four assistants still on the ground!

1908–09 GYROPLANE NO. 2

Bréguet and Richet's Gyroplane No. 2 had only two rotary wings with a diameter of 25 feet 9 inches (7·85 metres) fitted on to uprights tilted slightly forward. It also had aircraft controls and fixed wings with a lifting surface of 538 square feet (50 square metres). After several flights this helicopter crashed on 22 July 1908, falling on its tail from a height of approximately 33 feet (10 metres).

1935 BRÉGUET-DORAND LABORATORY GYROPLANE

Under the aegis of a small company called Le Syndicat d'Etudes du Gyroplane (Gyroplane Study Consortium), Bréguet and René Dorand in 1931 started designing and trial work which continued until well into 1935. Then, on 22 September and 24 November 1936, the single-seater Laboratory Gyroplane set up a number of records (see under World Records).

The rotary-wing system consisted of two twin-bladed co-axial contra-rotating rotors, measuring 53 feet $9\frac{3}{4}$ inches (16·4 metres) in diameter, which were among the largest at that time.

When hovering, the Gyroplane was steered by making differential changes in the pitch of the two rotors. The blades were articulated freely about the hub. There was also an additional joint one-quarter of the length along the blade measured from the hub, the main purpose of which was to reduce stresses on the blade while changing pitch.

Longitudinal and lateral control were obtained by means of a cyclic pitch control, which at that time was an innovation.

The rotors turned at speeds from 114 to 138 r.p.m.

In 1938 the aircraft made its first successful landings with the engine cut and the rotors in auto-rotation.

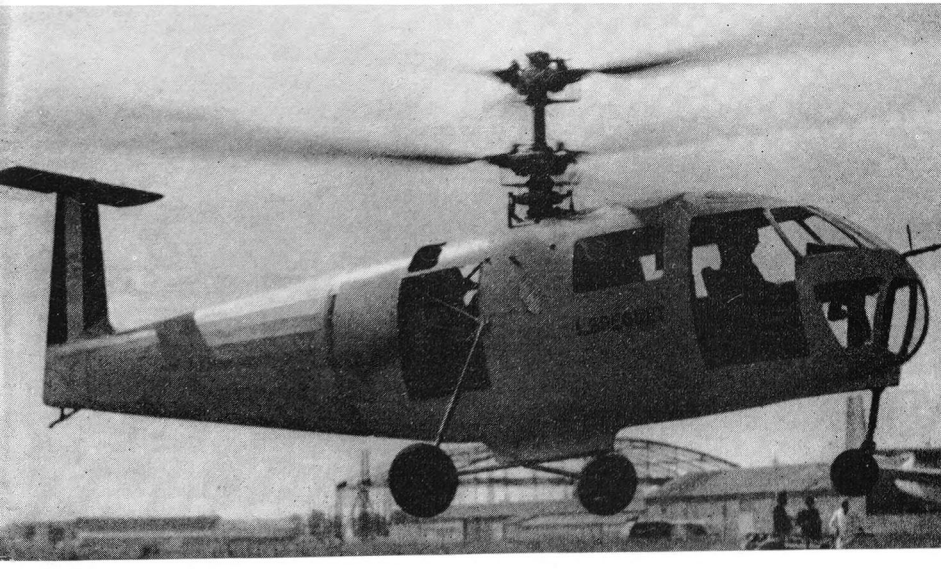
Trials with this Gyroplane continued right up till the outbreak of World War II, in the course of which it was destroyed.

1946 BRÉGUET G-IIE

The rotor system of this helicopter consisted of two three-bladed coaxial contra-rotating rotors. The blades were fully articulated, and damping was by rubber blocks for flapping motion and by friction dampers adjustable on the ground for motion in the rotor plane. The engine, placed in a mounting attached to a frame on the rear part of the fuselage, drove the rotors through a single-plate clutch.

The fuselage, constructed in light-metal alloy, carried on the rear section a tail unit consisting of a fixed vertical fin and a movable horizontal tailplane, both placed outside the circle swept by the rotor blades.

Engine: Potez 9 E-OO, 240 h.p.
Length: 32 ft $5\frac{3}{4}$ in (9·9 m)
Height: 13 ft $3\frac{1}{2}$ in (4·05 m)
Rotor diameter: 28 ft $2\frac{5}{8}$ in (8·6 m)



G-II E

Weight empty: 1,764 lb (800 kg)
Weight fully loaded: 2,915 lb (1,322 kg)
Cruising speed: 109 m.p.h. (175 k.p.h.)
max: 149 m.p.h. (240 k.p.h.)
Absolute ceiling: 13,123 ft (4,000 m)
Number of seats: 3

1950 BRÉGUET III

Since the engine in the G-IIE provided insufficient power, this prototype was enlarged to take a Pratt and Whitney 450 h.p. engine, and thus became the Bréguet III. This engine, incidentally, is the same as that used to power another aircraft with co-axial rotors, the American Gyrodyne GCA-2C. To enable work to be carried out on the engine, the rear section of the fuselage consisted of a single metal component, which could be removed.

Engine: Pratt and Whitney R-985-SB5, 450 h.p.
Length: 31 ft $9\frac{1}{8}$ in (9·68 m)
Height: 13 ft $10\frac{7}{8}$ in (4·24 m)
Rotor diameter: 31 ft 6 in (9·6 m)
Weight empty: 3,248 lb (1,473 kg)
Weight fully loaded: 4,629 lb (2,100 kg)
Cruising speed: 107 m.p.h. (173 k.p.h.)
max: 134 m.p.h. (215 k.p.h.)
Absolute ceiling: 15,748 ft (4,800 m)
Range: 292 miles (470 km)
Number of seats: 4

CANTINIEAU

When Aerotecnica SA of Madrid discontinued all work in the rotary-wing field, a French engineer named Cantinieau, who had already designed the MC-101 for Matra, returned to France. There he produced a new prototype known as Bamby, the rights for which were acquired by Sud Aviation.

1963 BAMBY

This prototype embodies a number of features which were tested during the time Cantinieau spent with Aerotecnica. The three-bladed rotor has no tail rotor but torque is corrected by means of a jet of compressed air at the tail—a system similar to that used on the AC-13 and the AC-14.

This light two-seater weighs 1,035 pounds (470 kilos) when empty; it is expected to cruise at 80 m.p.h. (129 k.p.h.).

DORAND

The year 1950 saw the establishment of the Société des Giravions Dorand. Dorand himself has long been a rotary-wing specialist. In 1924 he joined the Bréguet company, where he was in charge of airscrew experimental work. In 1931 he became technical director of the Syndicat d'Etudes du Gyroplane, which later produced the Bréguet-Dorand Laboratory Gyroplane. During its flying career in 1935-6 the latter broke several world records of the period.

When World War II broke out Dorand, in collaboration with Vullierme, was working on the G-20, a co-axial rotary-wing gyroplane.

In 1945 Dorand became head of the rotary-wing section of the Société Nationale de Constructions Aéronautiques du Centre. There he built the NC-2001, which made one flight in June 1949. A month later the company was wound up and Dorand went for a short time to the Société Nationale de Constructions Aéronautiques du Sud-Ouest, where he hoped to put the finishing touches to the NC-2001.

Finally, in 1950, he set up the Société des Giravions Dorand. This firm has produced the DH-011 and also a certain number of flight simulators which enable the behaviour of helicopters to be accurately predicted during design.

Dorand's chief concern is the use of gas flow to control the boundary layer at the blade tip. An experimental rotor with jet flaps, the Dorand DH-2011, was built and tested during 1964 in France prior to being sent to the United States for testing in the Ames wind tunnel.

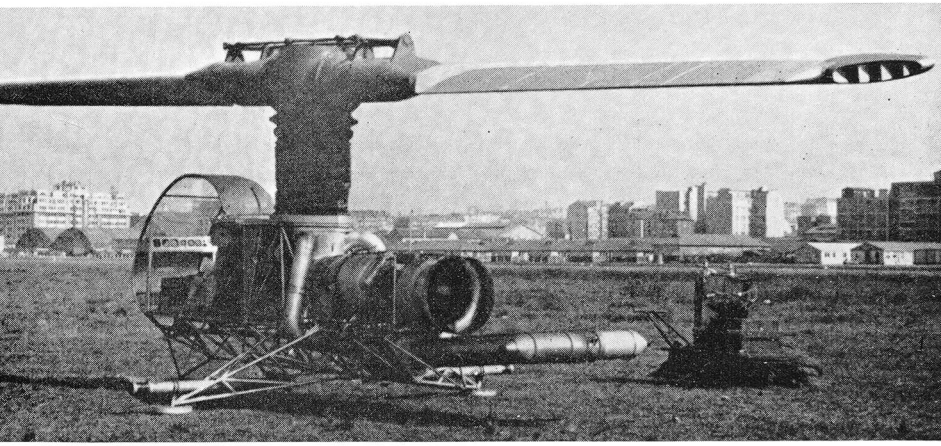
1952 DH-011

This aircraft was a flying mockup, working on the principle of moderate-pressure thermo-propulsion, and was intended to investigate a 'helicrane' concept.

To prevent the hot gases produced by the turbine from damaging the blade coverings on their way through, Dorand mixed the gases with compressed air supplied by a compressor, which reduced the temperature of the gases to about 284°F (140°C), while the pressure ratio was kept below 1:2. This rather low pressure ratio in relation to the amount of gases to be ejected meant that fairly large-diameter piping had to be used. The mixture was actually ejected through narrow slits one-thousandth of the depth of the blade and set on the latter's trailing edge. This procedure is known as 'blowing'.

The DH-011's power source was a gas turbine with auxiliary compressor: the hot air from the turbine was mixed with the cold air from the auxiliary compressor as it left the power unit, passed through the blades under the conditions described above, and was then ejected at a speed of 656 feet (200 metres) per second.

Engine: Turboméca Aspin I
Weight empty: 1,191 lb (540 kg)
Weight fully loaded: 2,260 lb (1,025 kg)
Theoretical ceiling: 19,685 ft (6,000 m)
Range: 124 miles (200 km)



DH-011

DH-015 (PROJECT)

This experimental two-seater was designed to be fitted with a Turboméca Soulor, and to work at a pressure ratio of 1:6.
Engine: Turboméca Soulor
Rotor diameter: 33 ft 9½ in (10·3 m)
Cruising speed: 186 m.p.h. (300 k.p.h.)
Range: 373 miles (600 km)
Number of seats: 2

DH-014 (PROJECT)

This rotorcraft was designed to use three Mamba turbo-propeller power units. The planned pressure ratio was 1:7.
Engines (3)*:* Armstrong Siddeley Mamba
Rotor diameter: 101 ft 8 in (31 m)
Cruising speed: 155 m.p.h. (250 k.p.h.)
Range: 218 miles (350 km)
Number of seats: 28

Dorand's development work on jet flaps has led to a co-operation agree-

ment between the Société des Giravions Dorand and the American firm L.T.V. Aerospace Corporation.

GAUCHER

In 1956 the Reverchon factory, situated in the suburbs of Paris, began building an individual helicopter designed by R. Gaucher. Gaucher was no newcomer to aviation: he already had several successful designs for light aircraft to his credit.

1957 RÉMICOPTER

This light individual helicopter has a two-bladed rotor powered by two pulse-jet engines in streamlined mountings. It was planned at a later stage to replace the present rotor blades by others made from a plastic material.

There is a large rudder, but no tail rotor.

The body consists of a chassis made from a jointless tube of large cross-section, to which are attached the pilot's seat, the undercarriage fitments and the bodywork.

The highly simplified controls number two only: one for cyclic control, the other for collective control.

The helicopter's main applications are observation duties and work on board ship.

Engines (2)*:* SNECMA pulse-jets
Length: 10 ft 6 in (3·2 m)
Height: 7 ft (2·15 m)
Rotor diameter: 19 ft (5·8 m)
Weight unloaded: 309 lb (140 kg)
Cruising speed: (max.) 81 m.p.h. (130 k.p.h.)
Range: 90 minutes (endurance)
Number of seats: 1

GIRAVIA

This company was founded in 1946 to study the application of thermo-propulsion to helicopters by two aeronautical experts of long experience: Georges Lepère and Robert Pouit.

Pouit had previously collaborated with Pescara (*q.v.* under Spain). Lepère had been connected with the aviation industry since 1909 and had, in fact, designed more than fifteen different types of aircraft. More particularly, in 1918, while in the United States, he was responsible for a well-known two-seater fighter.

In 1926 Lepère first became interested in rotary wings, and following contact with Juan de la Cierva he produced several autogyros, in France the CL-10, in the United Kingdom the CL-20 (for Westland) and one in the United States (for Pitcairn).

The underlying principle of thermo-propulsion is to pass the hot gases produced by a turbine through the helicopter blades and eject them from the tip. The blade coverings will be damaged by the hot gases unless protective steps are taken.

The scheme adopted by Pouit and Lepère consists of passing the hot gases through a stainless steel tube while simultaneously passing compressed air, which acts as an insulator, between the heated tube and the actual blade.

By this means Pouit and Lepère eject from the blade tip not a mixture of gases but very hot gases and cooler air at the same time. This method has one disadvantage: it increases losses due to friction.

1954 LP-10

This helicopter works on dual-flow equalized-pressure thermo-propulsion, i.e. the hot turbine gases and the air acting as an insulator are ejected separately but are both at the same pressure ratio of 1:5.

This system's yield has proved clearly higher than that of thermo-propulsion methods utilizing combustion at the blade tip.

The LP-10 was built by the Société Nationale de Constructions Aéronautiques du Sud-Ouest.

Engine: Turboméca Aspin
Number of seats: 2

1956 L-30 (PROJECT)

This was a private venture by Lepère aimed at improving his 1934 CL-20 built by Westland in the United Kingdom, by eliminating the CL-20's two shortcomings: lack of means to take off directly, and too low-powered an engine.

The rotor was unchanged, i.e. it had three blades articulating on a steel hub, with, in addition, collective pitch control.

Engine: Continental, 145 h.p.
Rotor diameter: 37 ft $0\frac{3}{4}$ in (11·3 m)
Weight empty: 915 lb (415 kg)
Weight fully loaded: 1,654 lb (750 kg)
Absolute ceiling: 14,764 ft (4,500 m)
Range: 311 miles (500 km)
Number of seats: 3

HELICOP-AIR

This firm of helicopter operators and Hiller dealers took up various projects by Lepère, an autogyro veteran with experience going back to the time of La Cierva. The autogyro built under the auspices of Helicop-Air was a modified version of the L-30, a project by Lepère going back as far as 1956.

1959 L-50 GIRHEL

This autogyro with two side-by-side seats, exhibited at the 1959 Le Bourget Air Show, was fitted with wings which provided most of the lift in level flight. A clutch and an engine driveshaft enabled the three-bladed rotor to be rotated for jump take-offs.

The engine drove a fixed-pitch propeller and the landing gear was of the classical type. At the tail there was a standard tailpiece with a central rudder and two vertical stabilizers. The estimated minimum speed was 19 m.p.h. (30 k.p.h.).

Although nothing came of this prototype, Lepère had planned a later version, the L-51, which would have been an L-50 equipped with a more powerful engine, a 150 h.p. Lycoming.

Engine: Continental, 90 h.p.
Length: 20 ft (6·1 m)
Width: (span) 19 ft $8\frac{1}{4}$ in (6 m)
Height: 6 ft $10\frac{5}{8}$ in (2·1 m)
Rotor diameter: 32 ft 10 in (10 m)
Weight empty: 661 lb (300 kg)
Weight fully loaded: 1,378 lb (625 kg)
Cruising speed: 87 m.p.h. (140 k.p.h.)
max: 103 m.p.h. (166 k.p.h.)
Range: 311 miles (500 km)
Number of seats: 2

LIORÉ AND OLIVIER

Lioré and Olivier, who had been engaged in aircraft manufacture since 1908, in 1913 built a 'helicoplane' for Vicomte Decazes to his design. This aircraft had two tandem wings, and two co-axial airscrews turning in opposite directions, mounted on a vertical axis and each measuring 13 feet $1\frac{1}{2}$ inches (4 metres) in diameter. The screws were driven by a 50 h.p. Gnôme engine. Tests of the aircraft ended with an unlucky accident, which brought its career to an abrupt end.

In 1932 Lioré and Olivier acquired a licence from La Cierva and started to build an autogyro.

Early in 1937 the Lioré and Olivier factories came under government control as the result of the 1936 nationalization laws, and were absorbed into the SNCASE group.

1932 AUTOGYRO CL-10

After detailed study of a La Cierva 19 Mark IV, Lioré and Olivier built a La Cierva C-27, known as the CL-10 (Cierva-Lepère) under the direction of Lepère (see under Giravia). This was a cabin autogyro with a direct-control head and also a mechanical-drive starting system. Directional control was obtained through a rudder.

There were neither stub wings nor ailerons. The rear strut was replaced by a tail wheel under the pilot's control, which greatly facilitated ground manœuvres.

Engine: Pobjoy, 75 h.p.
Rotor diameter: 32 ft 2 in (9·81 m)
Weight empty: 617 lb (280 kg)
Weight fully loaded: 1,080 lb (490 kg)
Cruising speed: min: 25 m.p.h. (40 k.p.h.)
max: 106 m.p.h. (170 k.p.h.)
Number of seats: 2

1936 AUTOGYRO C-301

This was the La Cierva C-30 built under licence. All the development and design work was done by Lioré and Olivier, and it was then taken over by the Société National de Constructions Aéronautiques du Sud-Est (SNCASE) when the French aircraft industry was nationalized. One hundred of these C-301s were built.

On the trailing edge of this aircraft's three independent blades were small tabs, which enabled stability to be improved by local changes in the shape of the blades.

The rotor mechanical-drive starting system was provided by a shaft which, issuing from the rear of the engine, engaged the hub via a secondary shaft, universal joint and a conical coupling. A plate clutch enabled this transmission to be cut out during flight.

Engine: Salmson 9 N, 175 h.p.
Length: 24 ft $3\frac{3}{8}$ in (7·4 m)
Height: 10 ft 6 in (3·2 m)
Rotor diameter: 37 ft $0\frac{3}{4}$ in (11·3 m)
Weight fully loaded: 1,940 lb (880 kg)
Cruising speed: min: 19 m.p.h. (30 k.p.h.)
max: 106 m.p.h. (170 k.p.h.)
Absolute ceiling: 13,123 ft (4,000 m)
Range: 2 hr 45 min (endurance)
Number of seats: 2

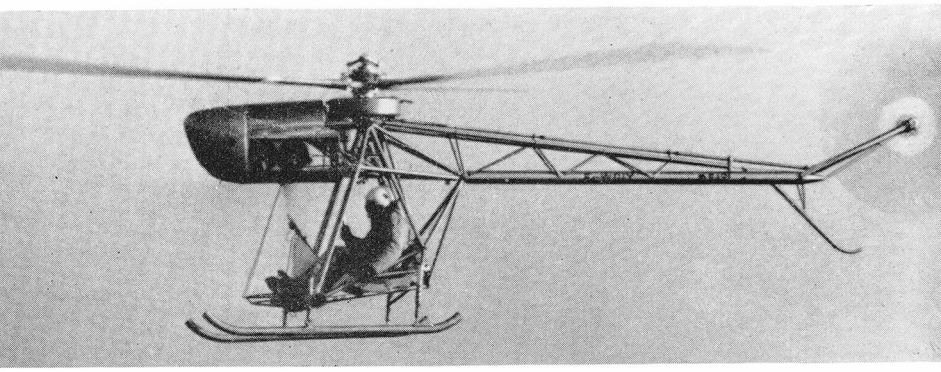
C-301

MATRA-CANTINIEAU MC-101, 1952

The Matra company produced for a young engineer, Paul Cantinieau, a helicopter designed by the latter and differing from most other such aircraft by its weight distribution. The engine, set horizontally towards the forepart and well above the cockpit, is placed in close proximity to the rotor. The only disadvantage of this theoretically admirable arrangement for stabilizing the helicopter is that the pilot's upward visibility tends to be reduced. The rotor exhibits the following unusual features: it consists of a universal hub mounted on a constant velocity joint with the result that all primary flapping is eliminated. Throughout their entire length the blades are untwisted and their thickness chord ratio is low. Furthermore, the relative position of the engine and rotor produces a reduction in the amplitude of transmission vibrations.

This helicopter, known as the MC-101, made its first flight with great success on 11 November 1952, and has since flown admirably, but none the less failed to find any market in France. Cantinieau therefore developed his ideas further on behalf of the Spanish firm, Aerotecnica. There the MC-101 became the AC-11, to be followed later by the AC-12 and AC-13, the latter powered by a gas-turbine engine (see under Spain).

Engine: Hirth HM-504, 105 h.p.
Length: 21 ft $11\frac{3}{4}$ in (6·7 m)
Height: 7 ft $6\frac{1}{2}$ in (2·3 m)



MC-101

Rotor diameter: 26 ft 3 in (8 m)
Weight empty: 882 lb (400 kg)
Weight fully loaded: 1,323 lb (600 kg)
Cruising speed: 62 m.p.h. (100 k.p.h.)
Range: 124 miles (200 km)
Number of seats: 2

ODIER-BESSIÈRES

Odier-Bessières' 'Clignogyro', which goes back to 1931, was in some respects intermediate between a fixed-wing aircraft and an autogyro.

A conventional Caudron C-193 low-wing monoplane, with a span of 37 feet 9 inches (11·5 metres), was fitted with a mast 39 inches (100 centimetres) high, carrying a four-bladed rotor 19 feet $8\frac{1}{4}$ inches (6 metres) in diameter.

The blade profile changed from the hub to the tip; near the hub it was set at a negative angle (for auto-rotation), which changed to a positive angle near the tip.

In 1932 this aircraft flew successfully a number of times by taking off after it had taxied some 20 yards (about 18 metres).

Engine: Renault, 95 h.p.
Weight fully loaded: 1,760 lb (798 kg)
Cruising speed: min: 20 m.p.h. (32 k.p.h.)
max: 80 m.p.h. (128 k.p.h.)
Number of seats: 2

OEMICHEN

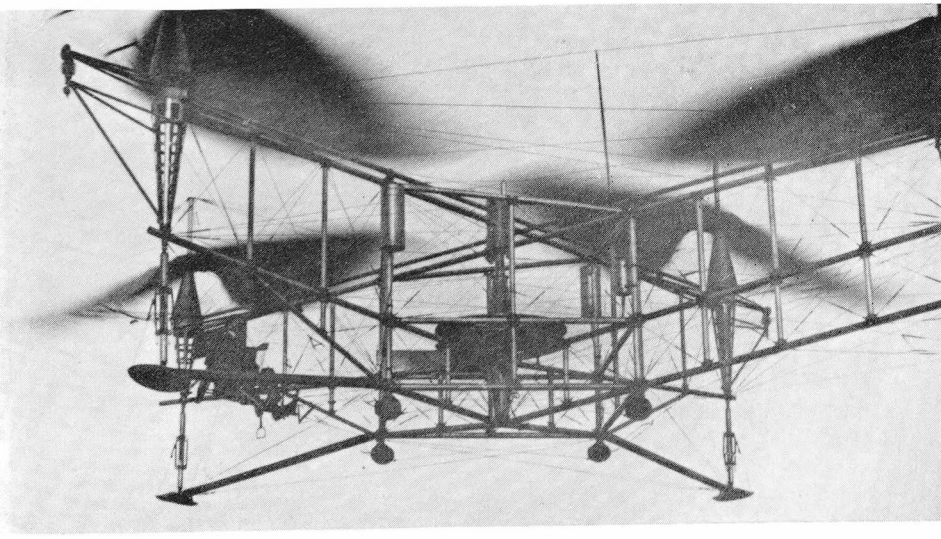
After the armistice which ended World War I Etienne Oemichen, an engineer at the Peugeot motor-car and bicycle firm, experimented continuously in the rotary-wing field.

Since his first apparatus, finished in 1920, failed to leave the ground, Oemichen simply added to it a balloon containing 5,088 cubic feet (144 cubic metres) of hydrogen, intended to supply the missing lift and to overcome the aircraft's instability. The aircraft had two two-bladed rotors 21 feet (6·4 metres) in diameter, placed at the two ends of a chassis made of wood and driven by a single 25 h.p. engine.

Oemichen's second aircraft had an impressive collection of rotors: four two-bladed ones (two of 24 feet $11\frac{1}{4}$ inches [7·6 metres] diameter, and two of 21 feet [6·4 metres]) provided lift. In addition, five small airscrews turning in the horizontal plane kept the aircraft level. There were also two further airscrews for propulsion, and finally, at the very front, an airscrew for steering. These six rotors and eight airscrews were powered by a single Le Rhône 120 h.p. rotary engine.

With this extremely complicated aircraft, Oemichen succeeded in flying 66 to 87 yards (60 to 80 metres) on 11 November 1922; with it he remained airborne for several minutes in May and July 1923, and finally at Arbouans on 24 May 1924 he flew 1 kilometre.

This was the aircraft which in 1924 set up the first closed-circuit



OEMICHEN NO. 2

distance record for helicopters confirmed by the F.A.I. (see under World Records).

For his next version Oemichen gave up this collection of windmills, which had lifted the aircraft only a few feet off the ground, and opted for a single rotor and two anti-torque airscrews before returning for good in 1938 to his first idea, which was much closer to a dirigible balloon than a helicopter.

PAPIN AND ROUILLY, 1915

Papin and Rouilly's 'Gyropter' possessed only a single hollow blade with a plan area of 15·12 square yards (12 square metres). The counterweight was a fan worked from a Le Rhône 80 h.p. rotary engine revolving at 1,200 r.p.m. to give an output of just over 247 cubic feet (7 cubic metres) of air per second. At the centre of gravity between the blade and the fan was the pilot's cabin. The fan drove air through the hollow blade, from which it escaped through an L-shaped tube at a speed of 328 feet (100 metres) per second.

Including the float on which it was mounted the aircraft weighed 1,102 pounds (500 kilos). Directional control was to be achieved by means of a small auxiliary pipe through which some of the air was driven, and which could be directed in whatever direction the pilot wished.

Tests were carried out on 31 March 1915 on Lake Cercey on the Côte d'Or, and a rotor speed of 47 r.p.m. was reached. Unfortunately the aircraft became unstable and the pilot had to abandon it, after which it sank.

RIGAULT-DEPROUX

In 1963 Rigault and Deproux, two engineers living in the suburbs of Paris, built a small autogyro glider. It was rapidly succeeded by a motorized version. The engineers planned to sell their rotorcraft in the form of kits.

1963 RD-1

This was an ultra-light rotating-wing glider built to gain experience for building an enlarged RD-2.

1964 RD-2

This version of the RD-1 is equipped with a Continental engine driving a fixed-pitch wooden pusher propeller, measuring 4 feet 3 inches (1·3 metres) in diameter. The two-bladed rotor is made in light alloy and ply-

wood to a Clark Y aerofoil section. The open fuselage structure is of square section light-alloy tubing.

Tests started in 1965. Since then the builders have considered changing it into a two-seater by means of a flat-four 105 b.h.p. Potez engine.

RD-3 is the designation for a two-seater autogyro version of the RD-2. Powered by a Potez 4-E-20 engine of 105 h.p., it underwent its first trials towards the end of 1966.

Engine: Continental, 65 h.p.
Length: 10 ft $9\frac{7}{8}$ in (3·3 m)
Height: 6 ft $10\frac{5}{8}$ in (2·1 m)
Rotor diameter: 21 ft (6·4 m)
Weight empty: 370 lb (168 kg)

SOCIÉTÉ FRANÇAISE DU GYROPLANE

When the Bréguet-Dorand Gyroplane had successfully flown, the Société Française du Gyroplane was set up shortly before World War II with Dorand, Bréguet and Vullierme for the purpose of building a co-axial-rotor helicopter.

1946 G-20

This prototype had two three-bladed co-axial contra-rotating rotors and two engines. Its building was supervised by Vullierme.

Engines (2)*:* Renault, 240 h.p. each
Length: 36 ft 4 in (11·08 m)
Height: 10 ft 3 in (3·12 m)
Rotor diameter: 50 ft 6 in (15·4 m)
Weight empty: 3,086 lb (1,400 kg)
Weight fully loaded: 5,512 lb (2,500 kg)
Cruising speed: 111 m.p.h. (179 k.p.h.)
Range: 455 miles (732 km)
Number of seats: 3

SOCIÉTÉ NATIONALE DE CONSTRUCTIONS AÉRONAUTIQUES DU CENTRE (SNCAC)

This company came into being in 1937 as the result of a 1936 law which nationalized the French aircraft industry. At the outset the Société Nationale de Constructions Aéronautiques du Centre embraced factories which had previously belonged to Farman and to Hanriot.

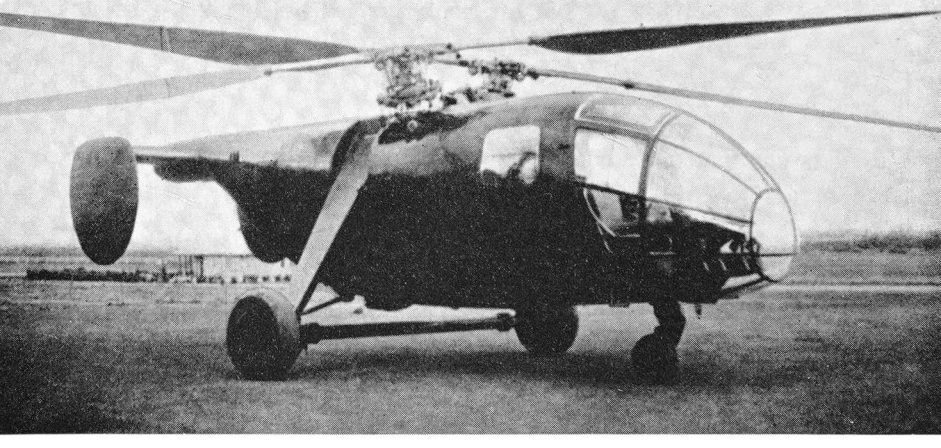
In 1949 SNCAC, as it was familiarly known, was wound up.

1946 NC-2001

Dorand, who is at present with the Giravions Dorand company (*q.v.*), built this helicopter with two intermeshing rotors of the so-called 'egg-beater' type. The ends of the blades were fitted with steel inertia blocks, the purpose of which was to reduce vibration and increase inertia. Instead of standard ball-bearing, roller, or thrust bearings, the blade pivot joints were fitted with rubber thrust bearings and torsion bars.

This helicopter flew once only, and was then abandoned when SNCAC closed down.

Engine: Renault, 450 h.p.
Length: 31 ft 10 in (9·7 m)
Rotor diameter: 49 ft 2½ in (15 m)
Weight fully loaded: 5,620 lb (2,550 kg)
Cruising speed: 99 m.p.h. (159 k.p.h.)
Inclined climb: 580 ft/min (176·8 m/min)
Absolute ceiling: 16,000 ft (4,880 m)
Number of seats: 5



NC-2001

PROJECTS

Before closing down, SNCAC was working on various 'convertible' projects resulting from German research work.

Project A was to have been a twin-fin monoplane with a four-bladed rotor attached to the fuselage nose and driven by jets at the blade tips. On the ground, it was to have rested on its tail and a supporting 'crutch'. The aircraft was to have taken off in this vertical position as a helicopter and would then have gradually converted into a horizontal position.

In landing, the process would be reversed. The aircraft would rear up into a vertical position prior to landing on its tail and 'crutch'.

Project B was to have had tilting rotors, one at each end of the wing and powered by gases ejected from the blade tips. The pilot would take off and to fly horizontally would have tilted the rotors forward, thus putting them in the position of fixed-wing airscrews.

Project C was based on changing the position of the fuselage while in flight.

At take-off this convertible would be standing on its tail. Its 'wing rotor', located behind the pilot's seat, would then be in a horizontal position. After take-off, the 'wing rotor' driven by the ejection of gases from the blade tips would lift the aircraft vertically like a helicopter, and when the required height was reached, the pilot would have tilted the fuselage forward and locked the 'wing rotor' so as to make it into a conventional fixed wing.

Nothing materialized from these various projects.

SOCIÉTÉ NATIONALE DE CONSTRUCTIONS AÉRONAUTIQUES DU NORD (SNCAN); now NORD AVIATION

Following the nationalization of the French aircraft industry in 1936, the following factories situated in northern France were grouped together under the general name Société Nationale de Constructions Aéronautiques du Nord, known as SNCAN for short: Potez, CAMS, Les Mureaux, Amiot and also a number of workshops belonging to Bréguet.

SNCAN's first helicopter prototype goes back to 1947. Late in 1956 SNCAN's name was changed to Nord Aviation.

1947 N-1700 NORELIC

The head of the twin-bladed rotor was designed to move parallel to the aircraft's longitudinal plane of symmetry, and also perpendicular to this plane. This arrangement consequently eliminated changes of angle and, of course, the secondary flapping brought about by the latter.

Collective pitch and also cyclic pitch were respectively controlled by the radial and flapping movements of small auxiliary blades set at 90 degrees to the main blades.

In this helicopter, the anti-torque device consisted of a fixed-pitch airscrew placed at the end of the tail and blowing backwards on to an assembly of suitably adjusted vanes.

Engine: Mathis, 170 h.p.
Length: 23 ft (7 m)
Height: 9 ft 10½ in (3 m)

Rotor diameter: 32 ft 10 in (10 m)
Weight empty: 1,124 lb (510 kg)
Weight fully loaded: 1,760 lb (798 kg)
Cruising speed: 81 m.p.h. (130 k.p.h.)
Inclined climb: 580 ft/min (177 m/min)
Absolute ceiling: 9,843 ft (3,000 m)
Range: 217 miles (350 km)
Number of seats: 2

1954 N-1750 NORELFE

N-1750 is the designation given by SNCAN to a helicopter which a Spanish company commissioned it to build to specifications by Cantinieau. In actual fact, the N-1750 is none other than the Aerotecnica's AC-13.

This aircraft is fitted with an Artouste turbine, but unlike the SNCASE SE-3130, does not possess an anti-torque rotor. For this purpose, use is made of the residual gases of combustion, which also serve to steer the helicopter.

For technical details, see under Spain, Aerotecnica AC-13.

SUD AVIATION

Today Sud Aviation is one of France's leading aircraft constructors. The group came into being on 1 March 1957, following the amalgamation of

N-1750

two nationalized firms: Sud-Est Aviation (formerly SNCASE) and Sud-Ouest Aviation (formerly SNCASO).

In the rotary-wing field, the new group is continuing with the mass production of the Alouette SE-3130 and the Djinn SO-1221, which it took over from the two previously independent firms.

To give a clearer picture of the development work each did prior to amalgamation, the various rotorcraft produced are listed separately under SNCASE and SNCASO.

SOCIÉTÉ NATIONALE DE CONSTRUCTIONS AÉRONAUTIQUES DU SUD-EST (SNCASE); now part of SUD AVIATION

Yet another of the companies set up as the result of the nationalization of the French aircraft industry in 1936, SNCASE grouped together various aircraft factories situated in south-eastern France and formerly owned by Potez, CAMS, Romano, SPCA and Lioré and Olivier. This accounts for the very wide range of both prototypes and aircraft since brought out by SNCASE.

Prior to nationalization, actually in 1932, Lioré and Olivier had acquired a licence to manufacture La Cierva autogiros. In 1937 SNCASE continued developmental work on the C-30 and then set about building an autogyro known as the SE-700. SNCASE's first helicopter, the SE-3000, was none other than the Focke Fa-223.

It should be added that SNCASE has obtained a licence to manufacture the Sikorsky S-55 in France. Subsequently from 1956 onwards the S-58 was also built. Under the aegis of Sud Aviation there appeared in 1962 a version of the S-58 known as the Bibastan. In this military rotorcraft the 1,525 h.p. Wright piston engine was replaced by a 1,900 h.p. twin Turboméca Bastan IV engine installation giving better performance at high altitude.

Late in 1956 SNCASE's name was changed to Sud-Est Aviation, and in March 1957 was merged with Sud-Ouest Aviation (ex-SNCASO) to form Sud Aviation. At the present day, along with Westland in the United Kingdom and Agusta in Italy, it is one of the largest helicopter firms in Western Europe.

AUTOGYRO 301 (C-301)

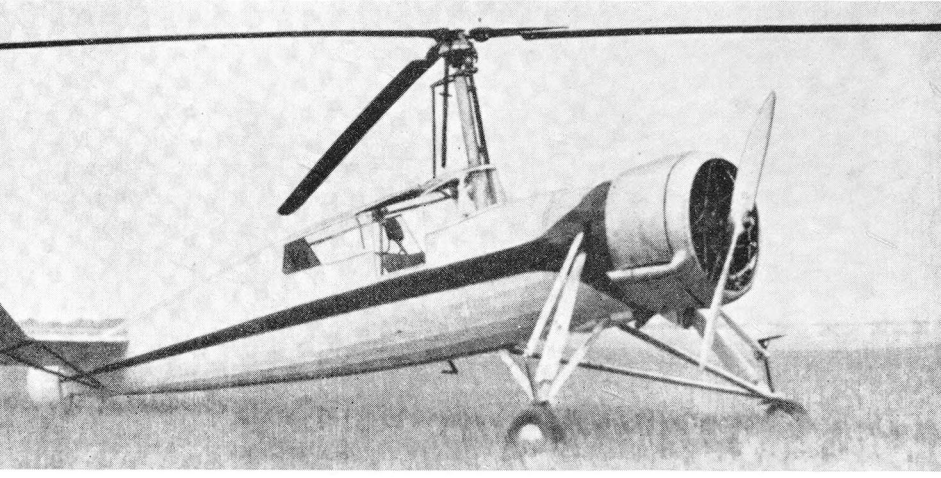
See Lioré and Olivier earlier in this chapter.

1937 C-34

This autogyro, built under licence from La Cierva, was one of the heaviest of its period: it weighed well over a ton and a half!

The rotor's three blades were articulated both horizontally and vertically: some 100 h.p. were used in setting the rotor in motion, and this operation was performed by means of a clutch.

Engine: Gnôme Le Rhône K-7, 350 h.p.
Length: 32 ft $1\frac{7}{8}$ in (9·8 m)
Width: (blades folded) 12 ft $1\frac{5}{8}$ in (3·7 m)
Weight empty: 3,638 lb (1,650 kg)
Weight fully loaded: 5,070 lb (2,300 kg)
Number of seats: 2

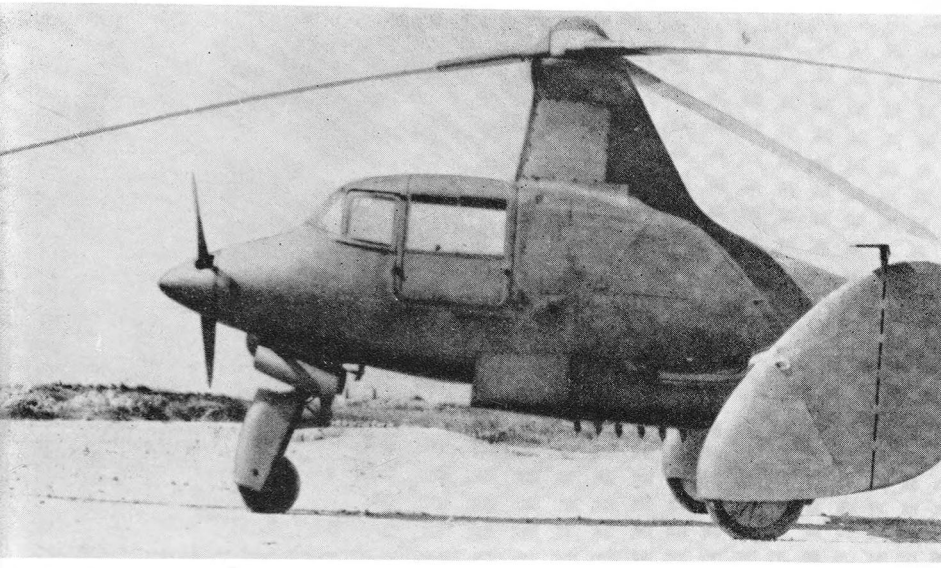


C-34

1945 AUTOGYRO SE-700

During the war, SNCASE worked on an autogyro known as the SE-700, which flew for the first time in 1945. This three-seater could take off from where it stood by changing the pitch of the rotor. The airscrew was also of the variable-pitch type.

Engine: Béarn 6 DO 5, 350 h.p.
Length: 21 ft $5\frac{7}{8}$ in (6·55 m)
Height: 12 ft $7\frac{5}{8}$ in (3·85 m)
Rotor diameter: 52 ft $5\frac{7}{8}$ in (16 m)
Cruising speed: 137 m.p.h. (220 k.p.h.)
min: 28 m.p.h. (45 k.p.h.)
max: 165 m.p.h. (266 k.p.h.)
Absolute ceiling: 14,764 ft (4,500 m)
Range: 410 miles (660 km)
Number of seats: 2



SE-700

1946 SE-3000

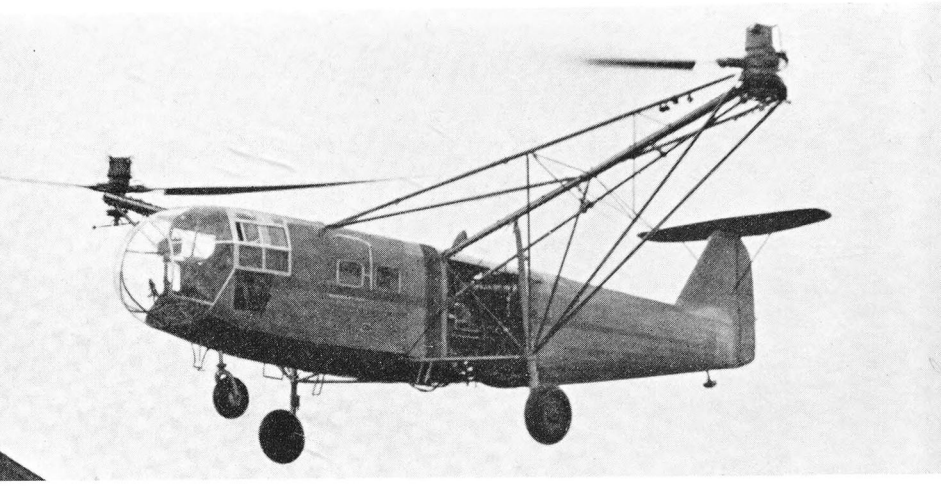
Maiden flight: 23 October 1948.

This SE-3000 is a development of the German helicopter Fa-223. Incidentally, Professor Focke himself took part in building the aircraft. Principally designed for transport purposes, this helicopter carried, in addition to the two-man crew, four passengers in a cabin situated behind the pilot's seat. This cabin was forward of the engine compartment. The aircraft was also equipped with a weight-lifting mechanism, which really turned it into a helicrane.

The fuselage was constructed of welded steel tubing. It was fitted with a fin and a rudder. The rotors, the centres of which were 41 feet (12·5 metres) apart, were carried on cantilever outriggers.

1946 SE-3101

The purpose of this experimental single-seater was to study the placing of auxiliary rotors intended simultaneously to provide torque correction and longitudinal control. Two rotors, with compressed wood blades 5 feet 3 inches (1·6 metres) in diameter, were placed symmetrically at 45 degrees, one on each side of a V-shaped beam at the end of the fuselage, which was made of welded tubes without a skin covering. These variable-



SE-3000

pitch airscrews enabled the aircraft to be steered by varying their pitch differentially.

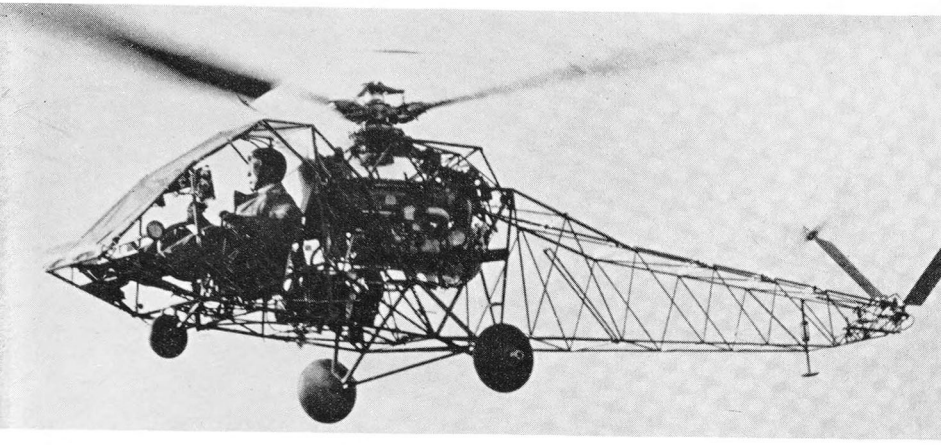
The helicopter flew for the first time on 1 June 1948.

Engine: Mathis, 85 h.p.
Length: 22 ft $7\frac{5}{8}$ in (6·9 m)
Height: 7 ft $4\frac{1}{2}$ in (2·25 m)
Rotor diameter: 26 ft $7\frac{1}{4}$ in (7·5 m)
Weight empty: 882 lb (400 kg)
Weight fully loaded: 1,146 lb (520 kg)
Cruising speed: 59 m.p.h. (95 k.p.h.)
max: 75 m.p.h. (120 k.p.h.)
Inclined climb: 649 ft/min (198 m/min)
Absolute ceiling: 9,843 ft (3,000 m)
Range: 62 miles (100 km)
Number of seats: 1

1947 SE-3110

This helicopter still relied on the twin-tail rotor system used in the experimental SE-3101, which acted against torque and for directional and longitudinal control. The maiden flight took place on 10 June 1950.

Engine: Salmson 9 NH, 200 h.p.
Length: 36 ft $6\frac{1}{4}$ in (11·13 m)
Width: 7 ft $10\frac{1}{2}$ in (2·4 m)
Height: 8 ft $6\frac{3}{8}$ in (2·6 m)



SE-3101

Rotor diameter: 39 ft 4½ in (12 m)
Weight empty: 1,477 lb (670 kg)
Weight fully loaded: 2,094 lb (950 kg)
Cruising speed: 71 m.p.h. (115 k.p.h.)
max: 99 m.p.h. (160 k.p.h.)
Inclined climb: 800 ft/min (244 m/min)
Absolute ceiling: 14,760 ft (4,500 m)
Range: 186 miles (300 km)
Number of seats: 2

1949 SE-3120 ALOUETTE (LARK) I

This three-seater was designed to meet a number of requirements in both military and civil use. It has proved an excellent aircraft for agricultural purposes.

It is a standard helicopter. Its rotor has three blades with three degrees of freedom: pitch, in-plane motion and vertical flapping. Pitch is controlled by means of a stabilizing gyroscope.

On 2 July 1953 this helicopter set up several world records (see under World Records).

Engine: Salmson 9 NH, 200 h.p.
Length: 34 ft 3½ in (10·45 m)
Width: 8 ft 7⅛ in (2.62 m)
Height: 9 ft 6⅛ in (2·9 m)
Rotor diameter: 38 ft 1 in (11·6 m)
Weight empty: 1,654 lb (750 kg)
Weight fully loaded: 2,536 lb (1,150 kg)

SE-3110

Cruising speed: 62 m.p.h. (100 k.p.h.)
max: 78 m.p.h. (125 k.p.h.)
Inclined climb: 886 ft/min (270 m/min)
Absolute ceiling: 13,120 ft (4,000 m)
Range: 140 miles (225 km)
Number of seats: 3

1955 SE-3130 ALOUETTE II

Successor to the SE-3120, the SE-3130 or Alouette II is fitted with a turbine giving 400 h.p. maximum and 320 h.p. in continuous running. Its speed of 35,000 r.p.m. is brought down by a two-stage reduction to 5,680 r.p.m. at the output shaft. The latter is directly connected to the rotor drive and auxiliary equipment drives. Through a planetary reduction gear, this speed is reduced to give the rotor 350 r.p.m. Control of the helicopter is considerably simplified by a device to regulate the rotor speed, which does away with any direct connection between gas flow and rotor pitch.

The SE-3130 made its maiden flight on 12 March 1955; three months later, on 3 June 1955, it broke the world all-comers' altitude record for helicopters, previously held by the Sikorsky S–59 (see under World Records).

This helicopter is mass-produced for both civil and military use.

The French Navy version, of 1956, has four-wheeled landing gear. In 1957 the American firm Republic Aviation Corporation was licensed by Sud Aviation to manufacture the Alouette II in the United States. Alouette II was successively equipped with an Artouste IIB, an Artouste IIC and finally an Artouste IIC6 turboshaft engine derated to 480 s.h.p.

SE-3120

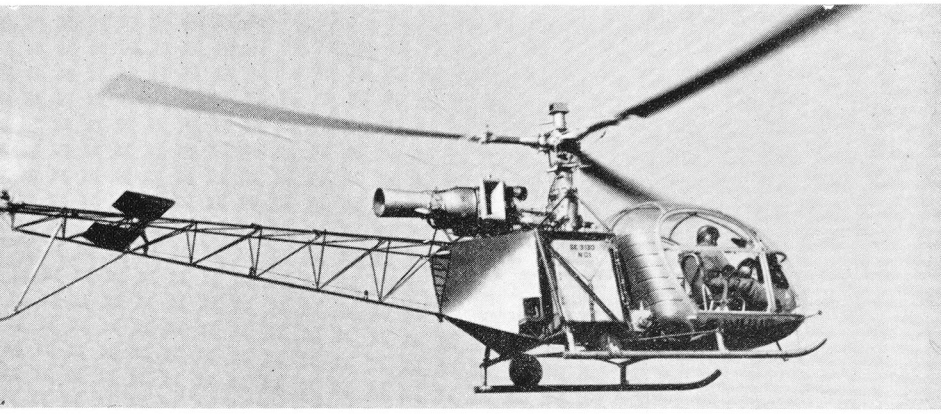
By the start of 1967, orders for 916 Alouette IIs had been received from more than 35 countries where it is in use.

Engine: Turboméca Artouste II
Length: 31 ft $8\frac{3}{4}$ in (9·67 m)
Width: 6 ft $9\frac{7}{8}$ in (2·08 m)
Height: 9 ft $0\frac{5}{8}$ in (2·76 m)
Rotor diameter: 33 ft $5\frac{5}{8}$ in (10·2 m)
Weight empty: 1,973 lb (895 kg)
Weight fully loaded: 3,307 lb (1,500 kg)
Cruising speed: 106 m.p.h. (170 k.p.h.)
Inclined climb: 13·8 ft/sec (4·2 m/sec)
Service ceiling: 14,764 ft (4,500 m)
Range: 329 miles (530 km)
Number of seats: 5

1957 SE-3131 GOUVERNEUR

This new helicopter, which was brought out as a product of Sud Aviation, first flew in May 1957. It was introduced to the public during the French International Air Show at Le Bourget soon afterwards. It is, in actual fact, none other than an Alouette helicopter in a streamlined version by the well-known expert Loewy.

Streamlining, by virtue of improved aerodynamic efficiency, gives the Gouverneur superior cruising speed.



SE-3130

Both the main and the anti-torque rotor are taken from the Alouette II, but to protect the latter, a bow-shaped tail skid is provided.

Much thought has been given to making the Gouverneur's cabin as comfortable as possible, particularly by means of sound-proofing. This was, however, only an experimental aircraft.

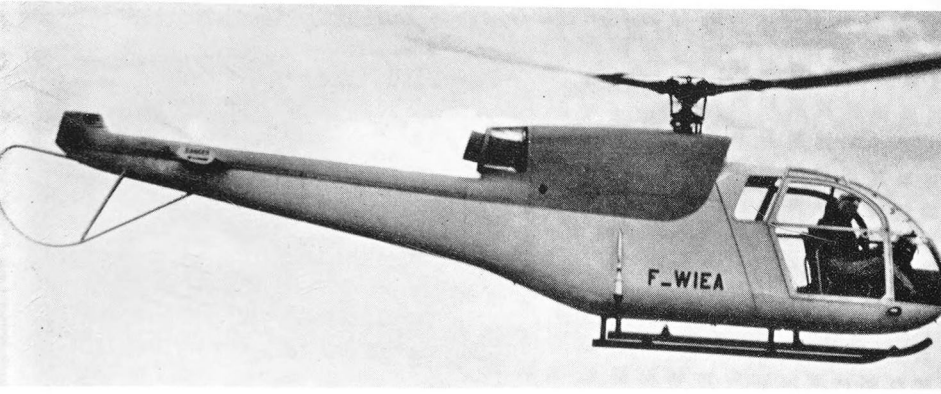
Engine: Turboméca Artouste II
Length: 31 ft $9\frac{7}{8}$ in (9·7 m)
Width: 6 ft $9\frac{7}{8}$ in (2·08 m)
Height: 9 ft $0\frac{5}{8}$ in (2·76 m)
Rotor diameter: 33 ft $5\frac{5}{8}$ in (10·2 m)
Weight empty: 2,039 lb (925 kg)
Weight fully loaded: 3,307 lb (1,500 kg)
Cruising speed: 121 m.p.h. (195 k.p.h.)
Absolute ceiling: 15,092 ft (4,600 m)
Range: 373 miles (600 km)
Number of seats: 5

1958 SE-3150

This experimental rotorcraft based on the Alouette II was equipped with an Artouste IIIB turbine engine, a rotor 36 feet $1\frac{1}{8}$ inches (11 metres) in diameter and an elongated tail beam. This precursor of the Alouette III was used to set up a world altitude record of 10,984 metres on 13 June 1958 at Brétigny-sur-Orge.

1961 SA-3180 ALOUETTE ASTAZOU

The Alouette SA-3180, which made its maiden flight on 31 January



SE-3131

1961, is an Alouette II equipped with an Astazou turbine engine instead of the Artouste on the Alouette SE-3130. In addition it has the main gearbox and main rotor shaft unit of the Alouette III while retaining the main and the anti-torque rotors of the Alouette II.

The 530 h.p. Astazou engine, though more powerful, is derated to 480 h.p., the power of the Artouste IIC6. The Alouette Astazou therefore has a lower fuel consumption than the Alouette II.

In 1965 tests were started with a view to using the German Bölkow rigid rotor for this aircraft. Early in 1966 an Alouette Astazou fitted with a three-bladed rigid rotor supplied by Bölkow started its flight trials.

Engine: Turboméca Astazou II, 530 s.h.p. derated to 480 s.h.p.
Length: 31 ft $9\frac{7}{8}$ in (9·7 m)
Width: 6 ft $9\frac{7}{8}$ in (2·08 m)
Height: 9 ft $0\frac{5}{8}$ in (2·76 m)
Rotor diameter: 33 ft $5\frac{5}{8}$ in (10·2 m)
Weight empty: 2,161 lb (980 kg)
Weight fully loaded: 3,307 lb (1,500 kg)
Cruising speed: 106 m.p.h. (170 k.p.h.)
Inclined climb: 16·4 ft/sec (5 m/sec)
Service ceiling: 15,420 ft (4,700 m)
Range: 516 miles (830 km)
Number of seats: 5

1959 SA-3160 ALOUETTE III

The Alouette III with a three-bladed rotor is an extrapolation of the Alouette II, fully streamlined apart from the turbine. This multi-purpose

light helicopter is powered by a turboshaft engine developing 870 s.h.p. and the power used on the helicopter, 550 s.h.p., is available up to 16,500 feet (5,030 metres).

It has a tricycle landing gear, hydraulic power controls and a range of quickly installed items of equipment. These, which include a cargo sling, rescue hoist, floats and so on, make it eminently suitable for civil and military use, and for both of these it is mass-produced. The maiden flight took place in February 1959. By 1968 orders for the Alouette III had been received from 48 countries.

It has many notable achievements to its credit: in June 1960 it reached a height of 15,780 feet (4,810 metres) on Mont Blanc, carrying seven passengers: in November 1960, carrying two pilots and 551 pounds (250 kilos) of freight, it reached a height of 19,690 feet (6,004 metres) on the Himalayan mountain of Deo Tibaa.

The mass-produced Alouette III is used by the land, air and sea forces of many countries and also by civil operators. It can be carried inside certain aircraft such as the C-130 Hercules, C-119 Packet, DC-6, etc.

An all-weather version of the Alouette III was developed in 1964 using a gyromatic compass, vertical gyro, a three-axis altitude and heading indicator, a radio altimeter, a Doppler radar and an automatic pilot. This version has been flying since 27 April 1964.

During that same year an armed version of the Alouette III, designated as the SA-3164, was developed to make it a weapons-system platform that could be equipped with a 20-millimetre cannon or air-to-surface missiles. The maiden flight of the SA-3164 took place on 24 June 1964. A Naval version has also been developed for shipborne operation with a pneumatic harpoon and a grid-deck-arrester system

1965 saw the first flight of an Alouette III experimentally fitted with an Astazou XII turbine which appreciably reduced the normal rate of fuel consumption. SA-319 is the designation of the production model equipped with an Astazou XIV.

Engine: Turboméca Artouste IIIB, 870 s.h.p.
Length: 32 ft $10\frac{7}{8}$ in (10·03 m)
Width: 8 ft 6 in (29·5 m)
Height: 9 ft $8\frac{7}{8}$ in (2·97 m)
Rotor diameter: 36 ft $1\frac{1}{8}$ in (11 m)
Weight empty: 2,435 lb (1,105 kg)
Weight fully loaded: 4,630 lb (2,100 kg)
Cruising speed: 118 m.p.h. (190 k.p.h.)
Ceiling: 15,420 ft (4,700 m)
Range: 311 miles (500 km)
Number of seats: 7

SE-3160

1959 SE-3200 FRELON

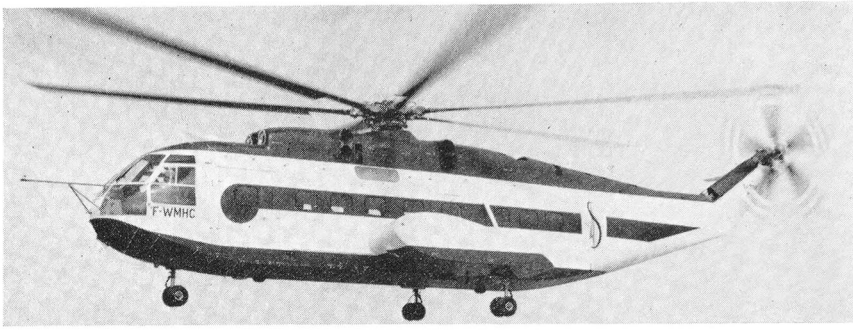
This experimental general-purpose helicopter has three engines and a four-bladed rotor. In the prototype the three turbines were mounted on top of the fuselage. Two engines are side-by-side in front of the rotor while the third is behind it; all work from a single transmission. The fuel is stored in external tanks placed on each side of and below the fuselage.

This all-weather aircraft has been developed for use both as a troop-transport and casualty-evacuation ambulance and as a naval aircraft equipped with sonar and able to carry 3,090 pounds (1,400 kilos) of anti-submarine devices.

Engines (3)*:* Turboméca Turmo IIIB, each 750 h.p.
Length: (blades folded) 48 ft $10\frac{5}{8}$ in (14·9 m)
Width: 17 ft $0\frac{5}{8}$ in (5·2 m)
Height: 15 ft 5 in (4·7 m)
Rotor diameter: 49 ft $2\frac{1}{2}$ in (15 m)
Weight empty: 10,362 lb (4,700 kg)
Weight fully loaded: 16,535 lb (7,500 kg)
Cruising speed: 134 m.p.h. (215 k.p.h.)
Ceiling: 10,827 ft (3,300 m)
Range: 622 miles (10,000 km)
Number of seats: 27

1962 SA-321 SUPER FRELON

Experienced gained with the Frelon led to the Super Frelon. The maiden flight took place on 7 December 1962. In July 1963 a specially streamlined prototype set up a world record on a 3 kilometre, 15/25 kilometre and a 100 kilometre closed circuit.



SA-321F

The Super Frelon, the prototype of which is designated SA–3210, is a medium-weight three-turbine amphibious aircraft. The production version shows considerable improvement over the SE-3200 by virtue of more powerful turbines and superior performance. The 1,500 s.h.p. Turmo IIIC3 engines used operate at a maximum of 1,290 s.h.p.

The turbines surround the main gearbox and are connected through mechanical drives with the main six-bladed rotor and the five-bladed anti-torque rotor. The rotors were designed by Sikorsky, the transmission system by Fiat of Italy. The blades are all-metal, interchangeable with each other and of the pretracked type. The rotor includes hydraulically assisted cyclic and collective pitch controls, hydraulic drag dampers and a centrifugal stop to reduce the angle of the blades' flap at low speeds. The Super Frelon's reserve of power is of the order of 20 per cent. The fuselage, the appearance of which recalls the hull of a hydroplane, is in light alloy and of semi-monocoque design. The rear of the cabin can be closed by a hinged rear-loading ramp.

The SA-321 is a helicopter fitted for night and for all-weather flying.

SA-321B is the designation for the Air Force and Army transport version.

SA-321D is the Super Frelon for the French Navy. The blades are foldable, as is also the boom carrying the tail rotor in order to facilitate handling on the lifts of aircraft carriers.

SA-321F, the civil version, made its maiden flight on 7 April 1967. It can carry from 34 to 37 passengers and also fly part of its load as freight.

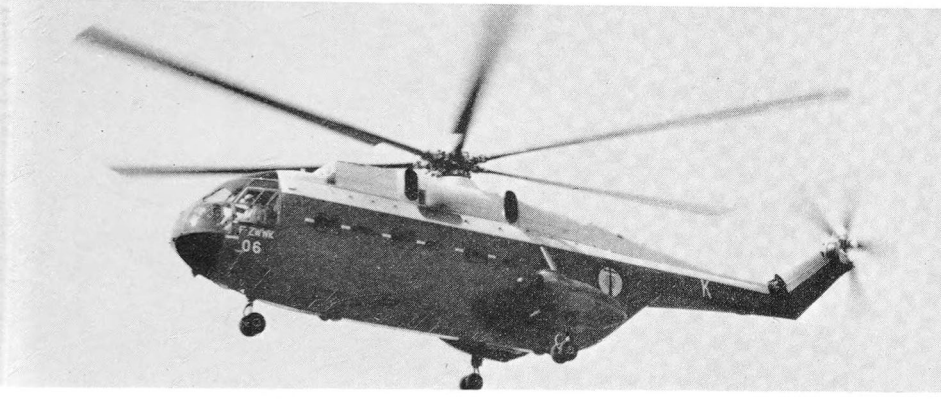
SA-321J is the aerial work version.

Engines (3)*:* Turboméca Turmo IIIC3, each 1,500 s.h.p.

Length: (blades folded) 65 ft $10\frac{5}{8}$ in (20·08 m)

Width: 17 ft $0\frac{5}{8}$ in (5·2 m)

Height: 21 ft 10¼ in (6·66 m)
Rotor diameter: 62 ft (18·9 m)
Weight empty: 13,933 lb (6,320 kg)
Weight fully loaded: 26,455 lb (12,000 kg)
Cruising speed: 152 m.p.h. (245 k.p.h.)
Inclined climb: 24·9 ft/sec (7·6 m/sec)
Ceiling: (in ground effect) 7,218 ft (2,200 m)
Range: 388 miles (625 km)
Number of seats: 33



SA-321D

1964 SA-330 PUMA

The SA-330, which made its maiden flight in April 1965, is a single four-bladed rotor, twin-turbine, tactical-transport helicopter and also a logistic vehicle. Externally it resembles the Sikorsky SH-3A but is somewhat smaller. It was particularly designed to fulfil the programme of tactical helicopters in the French ground forces' light aviation support. A pre-production run of five aircraft was launched in 1965.

One of this rotorcraft's main features is its reserve of motor power which at the SA-330's maximum weight is as high as 40 per cent.

Several unusual features have been tried on the SA-330 such as a landing gear fitted with a self-propelling hydraulic device. The SA-330 is included in the Anglo-French collaboration programme signed in 1967.

Engines (2)*:* Turboméca Turmo IIIC4, each 1,300 s.h.p.
Length: 48 ft 6¾ in (14·8 m)
Width: 11 ft 9¾ in (3·6 m)
Height: 16 ft 10⅜ in (5·14 m)

Rotor diameter: 49 ft $2\frac{1}{2}$ in (15 m)
Weight empty: 7,165 lb (3,250 kg)
Weight fully loaded: 14,110 lb (6,400 kg)
Cruising speed: 155 m.p.h. (250 k.p.h.)
Inclined climb: 23·6 ft/sec (7·2 m/sec)
Service ceiling: 16,404 ft (5,000 m)
Range: 332 miles (535 km)
Number of seats: 18

SA-330

1966 SA-340

The SA-340, originally designated the X-300, is a light helicopter intended to replace the Alouette II in the 1970s. It is designed to meet the requirements for LOH helicopters. The SA-340, fitted with the same transmission system as the Alouette Astazou, is powered by an Astazou turbine driving a three-bladed rigid rotor made of laminated fibreglass. The anti-torque rotor is a ducted tail rotor with 13 blades each measuring 2 feet 3 inches (0·686 metres) in diameter. This aircraft is included, with the SA-330, in the Franco-British Co-operation Agreement signed in 1967.

A first prototype made its maiden flight in April 1967. SA-341 is the designation of the production model.

Engine: Turboméca Astazou III, 600 s.h.p.
Length: 30 ft $10\frac{7}{8}$ in (9·42 m)
Width: 6 ft 4 in (1·93 m)
Height: 8 ft $3\frac{5}{8}$ in (2·53 m)

Rotor diameter: 34 ft $5\frac{3}{8}$ in (10·5 m)
Weight empty: 1,742 lb (790 kg)
Weight fully loaded: 3,527 lb (1,600 kg)
Cruising speed: 147 m.p.h. (237 k.p.h.)
max: 162 m.p.h. (260 k.p.h.)
Rate of climb: 2,067 ft/min (630 m/min)
Service ceiling: 21,982 ft (6,700 m)
Range: $4\frac{1}{2}$ hours (endurance)
Number of seats: 4–5

SA-340

SOCIÉTÉ NATIONALE DE CONSTRUCTIONS AÉRONAUTIQUES DU SUD-OUEST (SNCASO); now part of SUD AVIATION

Nationalization of the French aircraft industry in 1936 led to the constitution of the SNCASO group. To begin with, it covered the Marcel Bloch, SASO and UCA factories, part of the Lioré and Olivier workshops and the Blériot plant. The SNCASO started work on its first helicopter in 1946.

In March 1957 Sud-Ouest was amalgamated with Sud-Est to form a single company, Sud Aviation.

1946 SO-1100 ARIEL I

During World War II, SNCASO were seriously considering a jet helicopter, but the idea never really took shape until a number of Austrian specialists formerly in Doblhoff's team joined the group. It was this

which led to the appearance of Ariel I or SO-1100, which first flew in 1949.

The Ariel I's power source was a piston engine working a compressor which supplied compressed air to the combustion chambers placed at the tips of the rotor's three blades. The rotor had three leak-proof rotating joints to pass the compressed air and fuel, as well as an ignition distributor for the sparking-plugs in the combustion chambers.

Engine: Mathis G 7, 170 h.p.
Length: 13 ft 1¼ in (4 m)
Rotor diameter: 29 ft 6 in (9 m)
Weight empty: 948 lb (430 kg)
Weight fully loaded: 1,587 lb (720 kg)
Range: 124 miles (200 km)
Number of seats: 2

SO-1100

1948 SO-1110 ARIEL II

Unfortunately Ariel I lacked power. It was therefore redesigned as Ariel II, but the new version's piston engine still proved difficult to cool and the propulsion unit took on considerable weight because of the number of step-up gearings needed to work the Turboméca centrifugal compressor. This experimental helicopter flew for the first time on 21 April 1950

Engine: Mathis G 8, 200 h.p.
Length: 23 ft 5½ in (7·15 m)
Rotor diameter: 35 ft 5¼ in (10·8 m)
Weight empty: 1,521 lb (690 kg)
Weight fully loaded: 2,315 lb (1,050 kg)
Cruising speed: 71 m.p.h. (115 k.p.h.)
max: 93 m.p.h. (150 k.p.h.)
Range: 99 miles (160 km)
Number of seats: 2

SO-1110

1951 SO-1120 ARIEL III

Ariel III, derived from Ariel II, has not got a piston engine, but a 240 s.h.p. gas-turbine, which drives a centrifugal compressor directly. As in the earlier versions, the compressor feeds the compressed air through the hub and the blades right to their tips, where fuel is injected. The gas-turbine exhaust (which is not used for driving the rotor) is employed for directional control, especially for very low speed or hovering flight. For this purpose the exhaust is directed from the tubular tail through side exits fitted with deflector vanes. Ariel III's first flights took place in April 1951.

Engine: Turboméca Artouste gas-turbine, 240 s.h.p.
Length: 27 ft 2 in (8·28 m)
Height: 8 ft $7\frac{7}{8}$ in (2·64 m)
Rotor diameter: 35 ft $5\frac{1}{4}$ in (10·8 m)
Weight empty: 1,521 lb (690 kg)
Weight fully loaded: 2,646 lb (1,200 kg)
Cruising speed: 84 m.p.h. (135 k.p.h.)
max: 112 m.p.h. (180 k.p.h.)
Absolute ceiling: 11,811 ft (3,600 m)
Range: 155 miles (250 km)
Number of seats: 3

SO-1120

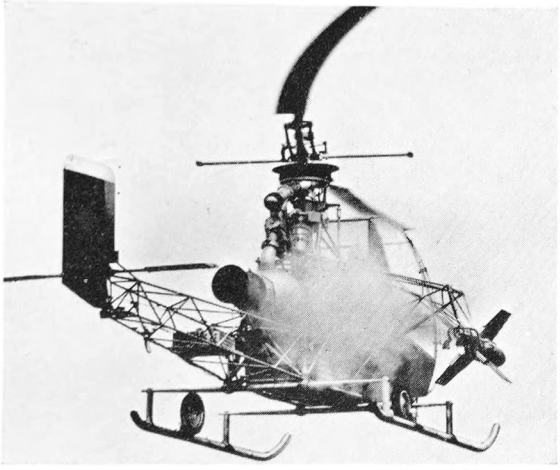
1953 SO-1220 AND SO-1221 DJINN

This, the world's first mass-produced jet helicopter, is outstanding in the simplicity of its conception. There are no combustion chambers at the tips of the blades. There is nothing more than a compressed-air generator with an output of 2,240 pounds (1,100 kilos) of air per second at a pressure of 38 pounds per square inch (2·7 kilos per square centimetre), air piping to the rotor hub, an air-tight joint in the hub, and hollow blades. Directional control is provided by a rudder placed in the engine exhaust, and this provides good manœuvrability even at zero speed.

The power actually taken up by the Djinn's rotor is roughly one-half of what would be produced by the same turbine and combustion chambers at the blade tips. But in that case, roughly as much fuel is used in the combustion chambers as in the turbine itself, so that the end-yield on the fuel used remains approximately the same.

The fuselage consists of a light and rigid framework in welded steel tubing and weighing about 66 pounds (30 kilos). The landing gear is made up of two skids to which two small wheels are attached for ground handling.

A noteworthy feature of the Djinn is that the all-metal blades are attached to the rotor hub by spring leaves, the flexibility of which enables pitch to be varied and allows the blades to flap. This method of attachment, which does away with ball and thrust bearings, is also employed on Ariel III, and had previously been used on the Doblhoff IV.



SO-1221

The maiden flight of SO-1220, the experimental Djinn, took place on 2 January 1953, while the SO-1221, the two-seater Djinn, first flew on 16 December 1953. A fortnight later this same aircraft broke the world altitude record for gyroplanes weighing less than 1,100 pounds (500 kilos) by reaching a height of 15,712 feet (4,789 metres). Early in 1957 a Djinn 1221 reached a height of 27,746 feet (8,458 metres), and thus surpassed by more than 650 feet (200 metres) the world altitude record for helicopters set up in June 1955 by the SE-3130.

Engine: Turboméca Palouste IV gas-turbine
Length: 17 ft $4\frac{5}{8}$ in (5·3 m)
Width: (with skids) 6 ft 4 in (1·93 m)
Height: 8 ft $6\frac{3}{8}$ in (2·6 m)
Rotor diameter: 36 ft $1\frac{1}{8}$ in (11 m)
Weight empty: 794 lb (360 kg)

Weight fully loaded: 1,764 lb (800 kg)
Cruising speed: 62 m.p.h. (100 k.p.h.)
max: 81 m.p.h. (130 k.p.h.)
Absolute ceiling: 14,764 ft (4,500 m)
Range: 112 miles (180 km)
Number of seats: 2

SO-1220

1953 SO-1310 FARFADET

This was the first French convertible. It can take off vertically, hover in the air and land vertically by means of its rotor, and fly forward at a speed greater than that of pure helicopters by means of a fixed wing and an airscrew fully independent of the rotor.

The change from one state to the other is accomplished without any change at all in the external appearance.

The SO-1310 is provided with two independent power units. In the rear is an Arrius II 360 h.p. Turboméca unit, which supplies the jet rotor with compressed air at take-off. The all-metal three-bladed rotor is identical with the one used in the SO-1120 Ariel III, but with a larger diameter.

In the forepart there is a Turboméca Artouste II turboprop engine with a take-off power of 360 h.p., operating a variable-pitch airscrew. During forward flight, the rotor originally used for take-off continues to auto-rotate, but with low lift, and the greater part of the lift is transferred to the fixed wing. Mounted over the fixed wing is the pilot's cabin, fitted with dual control, and in this cabin there is room for either three passengers, a freight load or two stretchers stacked on top of each other.

The Farfadet first flew in May 1953. It made its maiden flight, lasting about twenty minutes, as a true helicopter; the following one, on the same day, was made with the rotor and the airscrew respectively powered by their individual engines.

Engines: 1 Turboméca Artouste II gas-turbine forward
1 Turboméca Arrius II gas-turbine aft
Length: 33 ft $0\frac{7}{8}$ in (10·08 m)
Width: (wing span) 20 ft 8 in (6·3 m)
Height: 10 ft $11\frac{1}{8}$ in (3·33 m)
Rotor diameter: 36 ft $8\frac{5}{8}$ in (11·2 m)
Weight empty: 2,194 lb (995 kg)
Weight fully loaded: 3,329 lb (1,510 kg)
Cruising speed: (as helicopter) 96 m.p.h. (155 k.p.h.)
(as autogyro) 155 m.p.h. (250 k.p.h.)
Range: 249 miles (400 km)
Number of seats: 3

SO-1310

WEYMANN

Even prior to World War I, Weymann, well known as a motor-vehicle bodywork and components manufacturer, had taken part in many flying competitions throughout Europe and was also piloting hydroplanes.

During that war he built aircraft engines and in 1924 entered into

partnership with Lepère. The company was originally known as Weymann-Lepère, but a few years later was changed into a limited company, Etablissements Aéronautiques Weymann, which eventually ceased production altogether. During its active life from 1922 to 1934, it produced several aircraft and one autogyro prototype.

1930 CTW-200

This autogyro had a four-bladed rotor mounted on a pylon tilted 30 degrees forward. The blades were doubly articulated and restrained by stops from excessive movement. They were also attached to each other by cables intended to keep them apart when at rest.

The airframe was of steel tubes and there were side-by-side dual controls.

Engine: Renault, 95 h.p.
Length: 18 ft $0\frac{1}{2}$ in (5·5 m)
Width: (wing span) 21 ft $3\frac{7}{8}$ in (6·5 m)
Rotor diameter: 36 ft $1\frac{1}{8}$ in (11 m)
Weight empty: 992 lb (450 kg)
Weight fully loaded: 1,433 lb (650 kg)
Cruising speed: min: 19 m.p.h. (30 k.p.h.)
max: 93 m.p.h. (150 k.p.h.)
Absolute ceiling: 9,186 ft (2,800 m)
Range: 249 miles (400 km)
Number of seats: 2

Germany

The aeronautical world was taken by surprise on learning in 1937 that Focke had built a successful helicopter meeting all the requirements of the period for aircraft of that type. Surprise was greater when a short time later the same helicopter set up world records for altitude, endurance, speed and distance over a closed circuit.

World War II, which broke out shortly after the setting up of these records, provided German research workers with an opportunity for designing several new and original models.

AEG

The AEG helicopter designed by R. Schmidt in some respects resembled the Petroczy-von Karman aircraft used in World War I (see under Hungary). The AEG was attached to the ground by a system of three tethering cables which helped to stabilize it so that it could be used as an observation post, or, if need arose, as a support for an aerial.

The co-axial contra-rotating two-bladed rotors were driven by an electric motor located between them and fed with power through the three anchoring cables attached to girder-type arms fixed above the upper rotor. These tethering girders supported the observer's cabin; in the event of engine failure, the observer escaped by using a parachute blown into the air by a powder charge. The helicopter could be transported to the point where it was to be used in a special lorry fitted with a launching stand and a control desk.

1940 AEG

This helicopter was powered from the ground and tethered.
Engine: 220 h.p. electric motor
Rotor diameter: 26 ft (7·92 m)
Weight fully loaded: 2,701 lb (1,225 kg)
Ceiling: 3,281 ft (1,000 m)

BÖLKOW

After World War II two new firms came into being through the efforts of an engineer named Ludwig Bölkow. The first, Bölkow Apparatebau

GmbH, manufactures anti-tank missiles, light aircraft and the helitrainer BO-102. The second, Bölkow-Entwicklungen KG, works mainly to the orders of the Federal Republic's Ministry of Defence and is particularly concerned with rotary wings. The latter firm developed rapidly and late in 1959 took up a large shareholding in Wagen- und Maschinenbau GmbH, Donauwörth, and its sister company, Siebelwerke ATG GmbH.

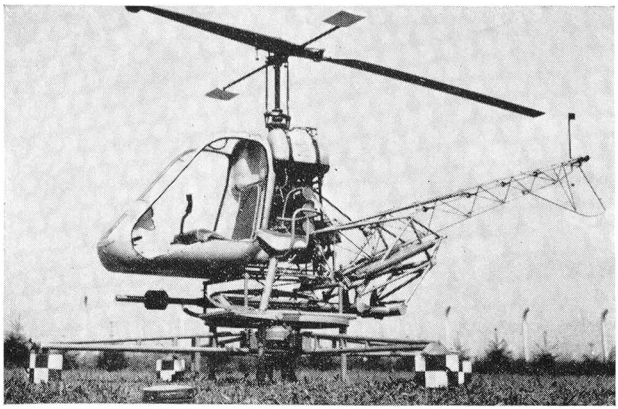
Since 25 June 1965, the firm, known as Bölkow GmbH, has had three partners, each with an equal share, and in 1968, this company merged with Messerschmitt AG thus becoming one of the largest manufacturing groups in the West German aerospace industry.

In the helicopter field Bölkow has tried out several interesting innovations and more particularly the Derschmidt rotor. This work was done under contract with the Federal Ministry of Defence for the development of a special lead-lag rotor system for high-speed flight. This rotor, based on the Derschmidt principle, has the advancing blades set backwards and the retreating blades set forward. The rotor produced by Bölkow is characterized by a relatively large internal part while the outer part of each blade can swivel through roughly 40 degrees.

Bölkow is also working on two other kinds of rotor, one rigid, the other on the so-called figure-eight system.

1960 BO-102

The BO-102 captive helitrainer was Bölkow's first success in the rotary-wing field. Developed in two versions, one land-based, the other water-based, the helitrainer can rise to a height of 2 feet (60 centimetres), turn around a vertical axis and dip within a limit of 6 degrees.



BO-102

A simple one-bladed rotor with a counterweight is driven by a two-stroke engine. The anti-torque rotor also has a single blade.

Engine: ILO L3, 40 h.p.
Length: 18 ft $7\frac{1}{4}$ in (5·68 m)
Width: 13 ft $4\frac{1}{2}$ in (4 m)
Height: 9 ft $8\frac{1}{2}$ in (2·96 m)
Rotor diameter: 21 ft 7 in (6·58 m)
Weight: (trainer) 717 lb (325 kg)
Ground support system: 981 lb (445 kg)
Number of seats: 1

1961 BO-103

This aircraft, directly derived from the land-based helitrainer BO-102, has the latter's airframe fitted with skids. This experimental helicopter is fitted with a single-blade rotor made of fibreglass. The blade consists of a single piece and a beam with an attachment lug for the counterweight. The 82 h.p. Agusta engine is more powerful than that used on the other helitrainer. Studies have been undertaken for the use of a 90 s.h.p. BMW gas-turbine and a 100 h.p. Wankel engine. The BO-103 flew in 1961 and 1962 under a Federal German Government contract.

1962 BO-104 (PROJECT)

This project for a light helicopter uses two light engines giving sufficiently high power to permit flight on one alone. The cargo compartment behind the pilot's cabin provides sufficient room to store one stretcher.

The special feature of this project, designed by an engineer named Weiland, is that it has a new rigid-type rotor without flapping or drag hinges.

Engines (2)*:* NSU-Wankel, 120 h.p. each
Rotor diameter: 24 ft 3 in (7·39 m)
Weight: (gross) 1,940 lb (880 kg)
Cruising speed: 112 m.p.h. (180 k.p.h.)
Range: $3\frac{1}{2}$ hours (endurance)
Number of seats: 2

1963 BO-105

The BO-105 was one of the projects selected in 1964 by the BDLRI (German Federal Aerospace Industry Association) and the BMWi (German Ministry of Economics) as part of the German civil aircraft requirements programme.

The BO-105 is an extrapolation of the BO-104 project. It takes the form of a multi-mission helicopter with a four-bladed rotor of the rigid type.

The small dimensions of the two turbines coupled to the main gear allow room for roughly 50 cubic feet (1·5 cubic metres) storage space

behind the cabin, which is also accessible through the rear doors. The fuel tanks are placed below the cargo compartment floor.

The two Allison T63 turbines in the prototype have been replaced by two MAN 6022-A3; use has also been made of a new hub in titanium. The first test flights took place in March 1967.

Engines (2): MAN 6022–701–A3, each of 350 s.h.p.
Length: (overall) 27 ft $10\frac{3}{4}$ in (8·5 m)
Height: 9 ft $6\frac{1}{8}$ in (2·9 m)
Rotor diameter: 32 ft $1\frac{7}{8}$ in (9·8 m)
Weight empty: 2,359 lb (1,070 kg)
Weight fully loaded: 4,409 lb (2,000 kg)
Cruising speed: 140 m.p.h. (225 k.p.h.)
max: 155 m.p.h. (250 k.p.h.)
Inclined climb: 1,772 ft/min (540 m/min)
Service ceiling: 19,685 ft (6,000 m)
Range: 279 miles (450 km)
Number of seats: 4

BO-105

1963 BO-46

Wind-tunnel tests with four- and five-bladed Derschmidt rotor systems proved that speeds of as high as 311 m.p.h. (500 k.p.h.) might possibly be expected. A flying test bed was therefore developed to try out this high-speed rotor system.

Three BO-46 research helicopters were built with fuselages manufactured by SIAT, Donauwörth. A high degree of vibration occurred during the initial trials which started in 1964.

Engine: Turboméca Turmo IIIB, 800 s.h.p.
Rotor diameter: 32 ft 10 in (10 m)
Weight fully loaded: 4,409 lb (2,000 kg)
Cruising speed: 249 m.p.h. (400 k.p.h.)
Number of seats: 2

BO-46

1963 BO P-310 (PROJECT)

The P-310 is a project for a winged rotorcraft transport. Two power plants each drive the Derschmidt rotors and propellers. The engines and the six-bladed rotors are mounted at the wing tips. In level flight two airscrews provide the greater part of the propulsive force. A combining shaft links the two separate transmission-gear assemblies for synchronization of the rotor systems' rotation and transmission of power between rotors during single-engine operation.

Engine: Lycoming T55, 3,200 h.p. each
Length: 60 ft (18·3 m)
Width: 73 ft $7\frac{7}{8}$ in (22·45 m)
Height: 21 ft $1\frac{7}{8}$ in (6·45 m)
Rotor diameter: 43 ft $3\frac{1}{8}$ in (13·2 m)
Weight fully loaded: 22,046 lb (10,000 kg)
Cruising speed: 311 m.p.h. (500 k.p.h.)
Range: 435 miles (700 km)
Number of seats: 27

BORGWARD

In 1956 the German motor-car firm of Borgward entered the helicopter field. Its team was led by Professor Heinrich Focke, a German helicopter specialist between the wars who spent a few years in Brazil after World War II. The Borgward helicopter started off as a private venture but was later sponsored by the Federal Ministry of Defence. Nothing came of the enterprise because the firm of Borgward went into liquidation.

1957 KOLIBRI I

This was the first German helicopter to be built after the end of World War II. The engine placed in the central section drove a three-bladed rotor. There was no control on the rotor hub itself but a hydraulic stabilization system held the resultant forces in the axis of rotation.

In the rear section there were two tail rotors set symmetrically in relationship to the tail, forming a right-angle.

The Kolibri flew for the first time at Bremen on 8 July 1958. It was piloted by Ewald Rohfls who had broken the helicopter world record for distance and altitude in 1937 in a Focke 61.

A larger version was also planned by the Borgward team.

Engine: Lycoming VO-435, 260 h.p.
Length: 27 ft 3 in (8·31 m)
Height: 10 ft (3·05 m)
Rotor diameter: 30 ft 10 in (9·4 m)
Weight empty: 1,764 lb (800 kg)
Weight fully loaded: 2,646 lb (1,200 kg)
Cruising speed: 87 m.p.h. (140 k.p.h.)
Ceiling: 14,764 ft (4,500 m)
Range: 249 miles (400 km)
Number of seats: 3

DORNIER

One of the oldest aircraft firms in Germany is the Dornier-Werke GmbH. This undertaking was in fact set up at Friedrischshafen in 1914 by Claude Dornier as a subsidiary of the Zeppelin works.

As far back as 1922 the prototype of the all-metal WAL flying boat made its first flight and was later widely used throughout the world, particularly in Amundsen's 1925 flight across the North Pole. In 1929 Dornier brought out its enormous 12-engined DO-X flying boat.

After World War II Dornier made a fresh start with short-take-off aircraft, the DO-27 and the DO-28. It also engaged in building under licence F-104 and G91s, in studies on vertical/short take-off and landing vehicles such as the DO-31, and also in a small single-seater helicopter at

the request of the Federal Ministry of Defence. This contract arose from the fact that before the war Dornier had taken out several patents relating to helicopters. Also in 1965 Dornier became a licensee to manufacture 250 Bell UH-1D helicopters for the Federal Ministry of Defence.

1962 DO-32

This is an ultra-light, collapsible single-seat jet helicopter. In some ways it is reminiscent of the first French SNCASO single-seater Djinn. The German rotorcraft uses the same principles: a two-bladed rotor driven by blade-tip ejection of compressed air without the use of combustion. The rotor has spring-leaf blades of the kind formerly developed by Theodor Laufer on the Doblhoff IV, the Djinn and finally the DO-32 of which he was the main designer.

Compressed air is supplied by a BMW compressor consisting of a gas-turbine coupled with a radial flow compressor. The unit weighs only 97 pounds (44 kilos) in all and operates at 45,000 r.p.m. The helicopter is steered by a rudder placed within the turbine exhaust.

The DO-32 can be folded up and placed in a container measuring 12 feet 6 inches × 2 feet $9\frac{1}{4}$ inches × 3 feet $3\frac{3}{4}$ inches (3·8 × 0·85 × 1·01 metres). The container can be towed on a two-wheel trailer behind a passenger motor-car.

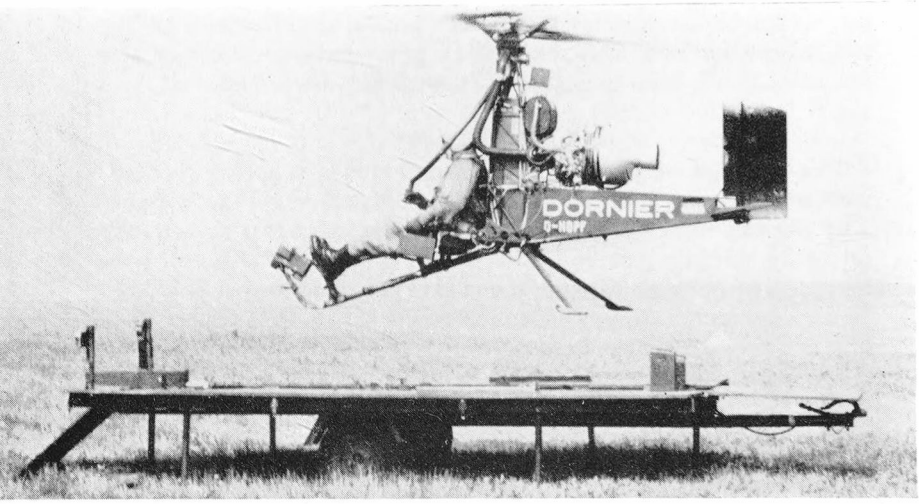
Following the first flight of the prototype on 29 June 1962, several others were built and one of them was sent to the United States firm of Ryan during 1964.

An unpiloted prototype carried out demonstration flights during 1966. Under the designation DO-32U, this is a ground-controlled reconnaissance DO-32 attached to the earth by a cable.

Engine: BMW 6012C, 90 s.h.p.
Length: 10 ft 6 in (3·2 m)
Height: 6 ft $2\frac{5}{8}$ in (1·89 m)
Rotor diameter: 24 ft $7\frac{1}{4}$ in (7·5 m)
Weight empty: 324 lb (147 kg)
Weight fully loaded: 595 lb (270 kg)
Cruising speed: 62 m.p.h. (100 k.p.h.)
Inclined climb: 13 ft/sec (4 m/sec)
Range: 56 miles (90 km)
Number of seats: 1

1964 DO-32Z

The DO-32 failed to achieve the sales which Dornier expected, so work was started on a new version with two seats, one behind the other. The new helicopter, like its predecessor, could be folded on to a trailer for transport by road. In the DO-32Z a BMW 250 s.h.p. 6022 replaces the BMW 6012 engine.



DO-32

1966 DO-32K KIEBITZ

The DO-Kiebitz is a mobile system consisting of a tether platform with a cross-country lorry used as a ground station. The payload of 121 pounds (55 kilos) can be stationed day and night at altitudes of up to 984 feet (300 metres).

The compressed air for the platform's tip-drive two-bladed rotor with a diameter of 24 feet $7\frac{1}{4}$ inches (7·5 metres) is supplied by a MAN 6012L air compressor mounted in the platform. The fuel supply is provided via the tether by means of a pump system installed in the mobile ground station.

1967 DO-132

This light four-seater is a development of the one-seater DO-32 tip-drive helicopter. Its main feature is a two-bladed tip-drive rotor powered by hot gas from a MAN 6022 hot-gas generator travelling via the rotor head and blades to the blade-tip nozzles where it expands.

Yaw control is ensured by a swept vertical tail unit and a control nozzle.

The latest DO-132 version uses a PT6A-20 gas-generator.

Engine: MAN 6022
Length: 23 ft $3\frac{1}{2}$ in (7·1 m)
Height: 9 ft $2\frac{1}{4}$ in (2·8 m)
Width: 6 ft $9\frac{1}{8}$ in (2·06 m)

Rotor diameter: 32 ft 10 in (10 m)
Weight fully loaded: 2,260 lb (1,025 kg)
Cruising speed: 115 m.p.h. (185 k.p.h.)
max: 124 m.p.h. (200 k.p.h.)
Service ceiling: 22,966 ft (7,000 m)
Range: 280 miles (450 km)
Number of seats: 4

DO-132

FLETTNER

Anton Flettner's start in the aeronautical industry goes back as far as 1905 when, on finishing his studies, he was employed by Zeppelin on development work into remote-control systems for lighter-than-air craft.

During World War I he perfected his servo-control, the Flettner tab, still in use today on almost every aircraft in the world.

During the 1920s he invented the Flettner rotor, a sort of rotating cylinder producing an aerodynamic force sufficient to move a vessel. The rotors were actually fitted to two ships, the *Buchau* and the *Baden-Baden*, on which they were mounted vertically on the top deck.

Flettner first entered the rotary-wing field in 1930 by designing a torqueless-drive helicopter with which some tethered tests were carried out in 1933, but a gust of wind destroyed this prototype. It had a two-bladed rotor 98 feet (30 metres) in diameter, each blade of which was fitted with a small Anzani 30 h.p. engine. In operation it was quite like Isacco's Helicogyro (see under Italy and U.S.S.R.).

Flettner next designed two autogyros, and then, eight years after his first helicopter, produced the Fl-265, the first helicopter in the world with intermeshing contra-rotating rotors.

The end of World War II put an end to Flettner's last project, the Fl-339, a large transport helicopter.

Flettner then emigrated to the United States, where he first became consultant to the Bureau of Naval Research and in 1949 founded his own company, the Flettner Aircraft Corporation (for the latter, see under United States of America).

1936 FL-184

This aircraft was a single-seater of the autogyro type with a Siemens-Halske engine. The rotor had cyclic pitch control.

In the course of its tests the Fl-184 caught fire and was completely destroyed.

Engine: Siemens-Halske 14, 140 h.p.
Rotor diameter: 39 ft 4½ in (12 m)
Number of seats: 1

1936 FL-185

This convertible-type aircraft, besides its three-bladed lifting rotor, had two variable-pitch airscrews mounted on either side on lateral outriggers, with thrust in opposite directions to counteract rotor torque.

The engine, situated in the nose, was cooled by a three-bladed adjustable fan consuming about 14 h.p., and in horizontal flight the remaining power was used to drive the outboard airscrews while the lifting rotor revolved by auto-rotation. The main gearbox was in the front part of the cockpit.

The Fl-185, which had a three-wheeled undercarriage, was given only a few tests near the ground, and then abandoned in favour of the Fl-265, which embodied the intermeshing-rotor system on which Flettner had now begun to work.

Engine: Siemens-Halske 14A, 140 h.p.
Rotor diameter: 39 ft 4½ in (12 m)
Weight empty: 1,700 lb (771 kg)
Weight fully loaded: 1,980 lb (898 kg)
Number of seats: 1

1938 FL-265

In 1937 Flettner began to design the first helicopter to use intermeshing contra-rotating synchronized rotors. The following year the German Navy gave Flettner an order for six of these single-seater helicopters, powered by a 7-cylinder air-cooled engine to drive its two intermeshing two-bladed rotors and with an inertia damping system to reduce the shake of the control stick.

The Fl-265's first flight took place in May 1939. During this flight the blades struck each other and the helicopter was destroyed. A similar fate

overtook the second one, because the pilot had forgotten to fill his fuel tanks. The remaining four Fl-265s in the original contract were extensively tested on the deck of a cruiser with such encouraging results that work was speeded up on the Fl-282, a second intermeshing-rotor helicopter designed to embody the experience acquired during tests of the Fl-265.

Engine: Bramo 14, 150 h.p.
Weight empty: 1,764 lb (800 kg)
Weight fully loaded: 2,205 lb (1,000 kg)
Cruising speed: (max.) 99 m.p.h. (160 k.p.h.)
Number of seats: 1

1940 FL-282 (KOLIBRI)

The Fl-282, a more advanced version of the Fl-265, worked on the same intermeshing-rotor principle and was intended to operate from cruisers for spotting work in anti-submarine patrols, and also for observer duties with anti-tank artillery.

The two intermeshing two-bladed rotors with hubs 2 feet (61 centimetres) apart were slightly inclined and connected to the engine by a worm gear drive. The blades, attached to the hubs by means of articulated hinges, each had a friction damper to limit flapping.

There were more than twenty variants of this helicopter, from the original single-seater prototype to the version with provision behind the rotor heads for a rear observer.

The Kolibri behaved so well even under the worst weather conditions —one landed on a gun-turret of the *Köln* during very heavy seas in the Baltic—that a series of 1,000 was decided on. The order was given to the Bayerische Motorenwerke, but the start of production was delayed by heavy air raids on the firm's factories.

Of the twenty-two actually completed, three only were found in serviceable condition after the war, and of these two were taken to the U.S.A. and one removed by the Red Army. Tests carried out in the U.S.A. by the Prewitt Aircraft Company confirmed the Kolibri's remarkable qualities.

Engine: Siemens-Halske 14A, 140 h.p.
Rotor diameter: (2) 39 ft $4\frac{1}{2}$ in (12 m)
Weight empty: 1,411 lb (640 kg)
Weight fully loaded: 2,205 lb (1,000 kg)
Cruising speed: 68 m.p.h. (109 k.p.h.)
max: 89 m.p.h. (144 k.p.h.)
Absolute ceiling: 12,992 ft (3,960 m)
Range: 106 miles (170 km)
Number of seats: 1–2

FL-282

1944 FL-339 (PROJECT)

This project, which never got beyond the drawing-board stage, was to have incorporated the experience gained with the Fl-282 and to have carried about a score of passengers. A BMW engine was to have been used.

Engine: BMW
Weight empty: 6,614 lb (3,000 kg)
Number of seats: 20–24

FOCKE

Since 1936 Heinrich Karl Johann Focke has been one of the leaders in the helicopter field. His interest in aeronautics predates World War I: as far back as 1909 he took part in building the primitive Focke aircraft 'Ente', and in 1912 was responsible for a monoplane fitted with a 50 h.p. Argus engine.

His A-7 was built a few years prior to the foundation of the Focke-Wulf Flugzeugbau A.G. early in 1924. The first aircraft produced by the new firm was the FW A-16 fitted with a Siemens engine and the first of a long line, including the A-32, A-33 Sperber, S-24 Kiebitz, A-43, A-47, etc.

In 1931 Focke's work led him to set up his own research laboratory, the equipment of which included a small wind tunnel. This research branch eventually budded off from the main firm and took the name of Focke-Achgelis GmbH, and under its aegis Focke carried out his investigations into rotary wings.

During World War II Focke continued his research work, still within the Focke-Achgelis framework.

At the end of World War II, Focke joined the SNCASE (*q.v.*) technical establishment in France, which had taken over the Fa-223, successor in Germany to the world-record-breaking Focke 61.

Focke eventually emigrated to South America where he continued his work on rotary wings.

1932 AUTOGYRO TYPE C-19

In 1931 Focke obtained a licence from La Cierva under which he built an autogyro derived from the Spanish C-19 Mark IV. It had a three-bladed rotor, stub wings, an elevator, rudder and ailerons, and mechanical-drive starting to set the rotor in motion.

The first flight took place in Bremen during 1932.

Engine: Siemens SK 14, 100 h.p.
Rotor diameter: 34 ft (10·36 m)
Weight fully loaded: 1,554 lb (705 kg)
Cruising speed: 60 m.p.h. (96 k.p.h.)
min: 19 m.p.h. (30 k.p.h.)
Number of seats: 2

AUTOGYRO C-19

1935 AUTOGYRO TYPE C-30

In 1935 Focke was granted a licence for the La Cierva C-30 two-seater 'direct-control'-head autogiro. It was planned to build forty of these rotorcraft.

1936 FOCKE 61

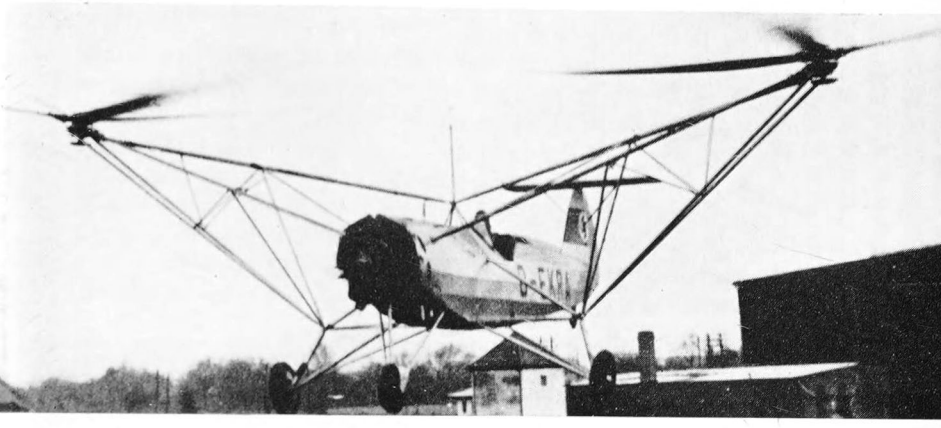
Professor Focke began his experiments in the pure helicopter field with a flying mock-up which had an 0·7 h.p. engine and an overall weight of just under 11 pounds (4·9 kilos). In 1934 this model reached a height of 59 feet (18 metres). There followed a long series of tests on power transmission to rotors carried out at the Brandenburger Motorenwerke, after which work on building the Model 61 was started. Finally, on 26 June 1936, an engineer named Rohfls made the first free flight and a year later he beat most of the existing world records for helicopters; in some instances his performances were fifteen times better than the preceding ones (see under World Records).

Although these records were confirmed by the F.A.I., they resulted in violent attacks upon Focke by von Asboth (see von Asboth under Hungary). Focke retorted: 'Von Asboth thinks he can prove that such an altitude could not be reached by a pure helicopter, but only if the aircraft were piloted as an autogyro . . . now what Mr von Asboth really thinks is that there are no good helicopters except those resulting from his work. All my record flights from beginning to end were pure helicopter flights; incidentally, all the landings were made vertically.'

In October 1937, piloted by Hanna Reitsch, this helicopter flew the $67\frac{3}{4}$ miles (109 kilometres) between Bremen and Berlin. In 1938 the same lady pilot gave a large audience a striking demonstration of the helicopter's ease of manœuvrability by a flying display inside the Berlin Deutschland-Halle.

The rotor had three articulated blades; longitudinal and directional control were provided by cyclic pitch. For lateral control, the angle of the blades on one rotor was increased while that of the other was decreased, thus producing a differential which gave excess lift on whichever side it was desired.

Engine: Bramo SH 14A, 160 h.p.
Rotor diameter: 23 ft (7·01 m)
Weight fully loaded: 2,101 lb (953 kg)
Cruising speed: 62 m.p.h. (100 k.p.h.)
Inclined climb: 722 ft/min (220 m/min)
Absolute ceiling: 7,907 ft (2,410 m)
Range: 142 miles (229 km)
Number of seats: 1



F-61

1938 FA-266

This scaled-up version of the F-61 was designed to have a side-by-side non-intermeshing rotor configuration. Various tests were made, starting late in 1939, and after the helicopter's first flight in August 1940 it was rechristened Fa-223 for military purposes.

1941 FA-223 (DRACHE)

This helicopter, an extrapolation of the F-61, had two side-by-side rotors mounted laterally on pyramid steel tube outriggers. These three-bladed rotors were attached to their respective hubs by articulated hinges which could flap in both the horizontal and the vertical planes. To limit their movement, friction dampers were provided.

The engine, located well behind the crew cabin, was kept in position by flexible rubber mountings in two rings, themselves attached to the four longitudinal members of the fuselage. Power was transmitted to the rotors via hollow tubular shafting running in bearings.

The fuselage was made of fabric-covered welded steel tube. There were two seats forward and behind them a cabin to carry four passengers or a freight load. Behind the cabin, as stated above, was the engine.

The landing gear consisted of three wheels fitted with oleo shock-absorbers and a spring-tail skid aft.

In flight this helicopter showed some instability at speeds below 62 m.p.h. (100 k.p.h.)

At the end of World War II the Fa-223 was revived both in France and in Czechoslovakia.

Engine: Bramo 323Q 3, 1,000 h.p.
Length: 40 ft 2½ in (12·26 m)
Width: 80 ft 4½ in (24·5 m)
Height: 14 ft 3⅝ in (4·36 m)
Rotor diameter: 39 ft 4½ in (12 m)
Weight empty: 7,496 lb (3,400 kg)
Weight fully loaded: 9,502 lb (4,310 kg)
Cruising speed: 75 m.p.h. (120 k.p.h.)
Inclined climb: 719 ft/min (219 m/min)
Absolute ceiling: 16,011 ft (4,880 m)
Range: 199 miles (320 km)
Number of seats: 6

1941 FA-284 (PROJECT)

This projected 'helicrane' was also to have side-by-side contra-rotating rotors at the extremities of outriggers. The two engines, originally of 1,600 h.p., and later of 2,000 h.p. each, were located at the centre of the transverse beam and operated the rotors through gear and shafting. The rotors were synchronized and could work on the engine alone.

The version with two 1,600 h.p. engines was planned to lift 2 metric tons, the version with two 2,000 h.p. engines, 7 metric tons.

Although development work on this helicopter had been virtually completed, only a few portions of the body had actually been built at the Bréguet factories in France by the time World War II ended.

Engines (2)*:* BMW 801, 1,600 h.p.
Length: 45 ft (13·72 m)
Rotor diameter: 59 ft 0⅝ in (18 m)
Weight empty: 18,000 lb (8,165 kg)
Weight fully loaded: 26,455 lb (12,000 kg)
Cruising speed: 129 m.p.h. (208 k.p.h.)
Absolute ceiling: 20,800 ft (6,340 m)
Range: 249 miles (400 km)
Number of seats: 2

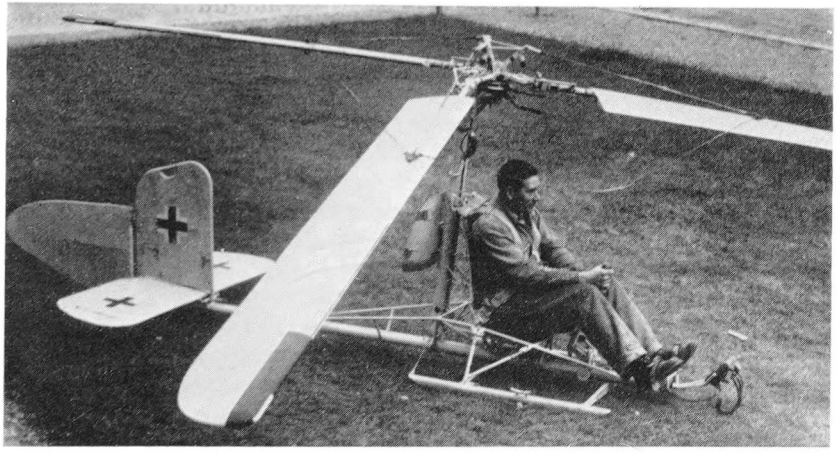
1942 FA-330 AUTOGYRO

By the end of World War II, some 200 of these small, motorless, three-bladed autogyros had been built for Focke-Achgelis by the Weser Flugzeugwerke at Delmenhorst. This rotorcraft was flown as a kite towed by a submarine from a cable 200 to 500 feet (61 to 150 metres) in length. The collapsible assembly was made of steel tubes, and just behind the pilot's seat was a pylon to support the rotor. The latter's hub was of the simplest possible autogyro type with flapping and drag hinges. The rotor was set in motion by a rope or by hand alone, if there was sufficient wind blowing. To bring the autogyro back, the towing rope was pulled in by

winch, and when the aircraft landed the rotor was brought to a standstill with a brake.

Training to handle this autogyro was given in a wind tunnel at Chalais Meudon in France. An original Fa-330 is still preserved in the French Air Museum.

Engine: None
Rotor diameter: 24 ft (7·32 m)
Weight empty: 180 lb (81·5 kg)
Cruising speed: 25 m.p.h. (40 k.p.h.)
min: 16 m.p.h. (25 k.p.h.)
Number of seats: 1



FA-330

1942 FA-325 AUTOGYRO GLIDER

This rotary-wing glider consisted of the fuselage of a DFS-230 glider, the wings of which had been replaced by an Fa-223 rotor. With a gross weight of 2,000 pounds (905 kilos), it was to be hauled at a speed of about 120 m.p.h. (192 k.p.h.) by a Junkers 52, and would then be able to land within not more than 20 yards (roughly 18 metres). During World War II this glider was never put to practical use.

Rotor diameter: 39 ft 4½ in (12 m)

KINDERMANN

The experimental helicopter built by this engineer was intended to test a special contra-rotating rotor system. The three-cylinder rotary engine

directly drives the principal rotor to which it is in addition rigidly attached. Torque control is provided by a two-bladed rotor mounted co-axially but rotating in the opposite direction.

The fuselage is very compact and fitted at the tail with a steering rudder. The helicopter underwent trials in 1961.

Engine: 90 h.p.
Length: (fuselage) 11 ft $9\frac{3}{4}$ in (3·6 m)
Height: 7 ft $2\frac{5}{8}$ in (2·2 m)
Rotor diameter: 17 ft $0\frac{3}{4}$ in (5·2 m)
Weight fully loaded: 948 lb (430 kg)
Cruising speed: 99 m.p.h. (160 k.p.h.)
Number of seats: 2

MERCKLE

The firm of Merckle Flugzeugwerke set about building a standard helicopter as a private venture. One of its designs powered by a Turboméca Artouste turbine resembles the French Alouette II. The Federal German Government eventually took an interest in helicopters of this kind.

1960 SM-67

This helicopter has a three-bladed main rotor and a two-bladed anti-torque tail rotor. The prototype financed by the Federal Government started its evaluation flights in April 1961 after long development work to eliminate the trouble caused by vibrations in the first prototype tested in July 1959.

Engine: Turboméca Artouste IIC, 400 s.h.p.
Length: 32 ft $10\frac{1}{2}$ in (10·02 m)
Height: 9 ft $2\frac{1}{4}$ in (2·8 m)
Rotor diameter: 34 ft $5\frac{3}{8}$ in (10·5 m)
Weight empty: 2,271 lb (1,030 kg)
Weight fully loaded: 3,748 lb (1,700 kg)
Cruising speed: 118 m.p.h. (190 k.p.h.)
Inclined climb: 984 ft/min (300 m/min)
Ceiling: 13,451 ft (4,100 m)
Range: 186 miles (300 km)
Number of seats: 5

SIEMETZKI

In 1959 at Kirchdorf, Alfons Siemetzki started to build a standard small helicopter, which he tried to simplify to the utmost by using standard aircraft or motor-industry parts whenever possible.

1959 ASRO-3(T)

In appearance this is a two-bladed teetering-rotor helicopter with a fuselage made of an uncovered steel tube structure, an open cabin and a skid undercarriage. The ASRO-3 flew in October 1959 and the ASRO-3T in December 1961.

Engine: BMW 6002
Length: 26 ft 3 in (8 m)
Height: 6 ft 10⅝ in (2·1 m)
Rotor diameter: 21 ft 3⅞ in (6·5 m)
Weight empty: 463 lb (210 kg)
Weight fully loaded: 842 lb (382 kg)
Cruising speed: 65 m.p.h. (105 k.p.h.)
max: 75 m.p.h. (120 k.p.h.)
Inclined climb: 886 ft/min (270 m/min)
Ceiling: 12,467 ft (3,800 m)
Range: 99 miles (160 km)
Number of seats: 1

1964 ASRO-4

This is a two-seater, turbine-powered development of the foregoing helicopter. The fuselage is in welded steel covered with aluminium sheet.

The rotor's three blades are attached through lead and lag hinges. The prototype started its ground tests in May 1964 and made its maiden flight during the summer of the same year.

Engine: BMW 6012, 100/130 s.h.p.
Length: (fuselage) 18 ft 11⅝ in (5·78 m)
Height: 7 ft 11⅝ in (2·43 m)
Rotor diameter: 23 ft 8¼ in (7·22 m)
Weight empty: 463 lb (210 kg)
Weight fully loaded: 1,025 lb (465 kg)
Cruising speed: 90 m.p.h. (145 k.p.h.)
max: 99 m.p.h. (160 k.p.h.)
Inclined climb: 951 ft/min (290 m/min)
Service ceiling: 15,748 ft (4,800 m)
Range: 1 hr 20 min (endurance)
Number of seats: 2

VFW

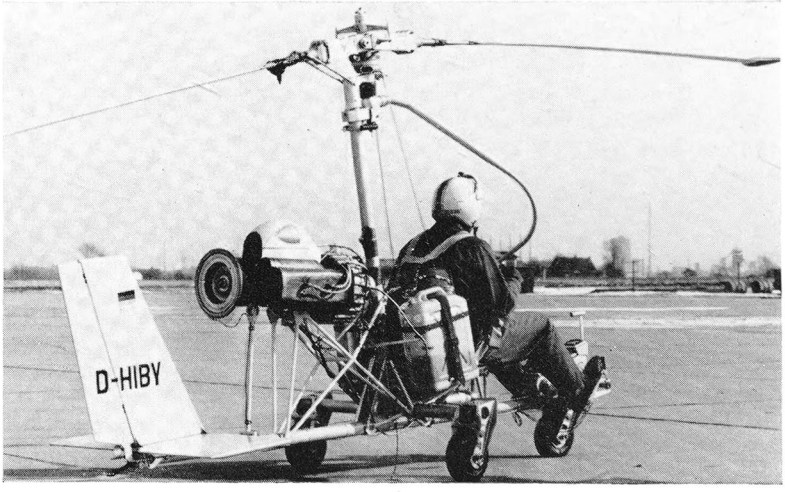
This abbreviation stands for Vereinigte Flugtechnische Werke, an association between Weser Flugzeugbau, Focke-Wulf and Heinkel. In 1964–5 VFW, some of whose members had been connected with the Sikorsky

S-64 Skycrane and the German WFS-64A, started to work on an ultra-light aircraft based on a Bensen-type autogyro.

1964 H-2

The experimental H-2 is a kind of marriage between a Bensen Gyro-Copter and a principle similar to that used on the Dornier. Indeed, the engine drives not only a pusher propeller but also a small centrifugal propeller sending air to the tips of the rotor's two blades.

It is planned to develop the H-2 into a two- or three-seater aircraft by replacing the 72 h.p. two-stroke McCulloch engine by one of much greater power.



VFW H-2

1967 H-3

Developed from the H-2 test vehicle, the H-3 is a compound helicopter using compressed air at the three rotor blade tips. In forward flight, two lateral shrouded propellers are used.

H-5 is a five-seater enlarged version of the compound H-3.

Rotor diameter: 28 ft 6½ in (8·7 m)
Weight fully loaded: 2,127 lb (965 kg)
Cruising speed: 112 m.p.h. (180 k.p.h.)
Inclined climb: 1,575 ft/min (480 m/min)
Range: 280 miles (450 km)
Number of seats: 3

WAGNER

Joseph Wagner started to show interest in helicopters in about 1960. After overcoming several teething troubles, his team produced a satisfactory machine which performed well at the 1966 Hanover Air Show.

1965 SKY-TRAC

The Sky-Trac has two contra-rotating two-bladed rotors. The rotor drive is through a special angle gear box. The airframe is of tubular steel and incorporates the engine, gear box and complete control system as a unit connecting with the lift rotors.

Height: 12 ft 5½ in (3·8 m)
Rotor diameter: 32 ft 10 in (10 m)
Weight empty: 1,521 lb (690 kg)
Weight fully loaded: 3,263 lb (1,480 kg)
Cruising speed: 87 m.p.h. (140 k.p.h.)
Range: 124 miles (200 km)
Number of seats: 1–3

1966 AEROCAR

This helicopter is developed from the basic Sky-Trac. This four-seater vehicle has an automobile-type cabin with a firewall forming the rear cabin bulkhead and separating the cabin from the engine.

This helicopter can be self-propelled on the ground through a hydraulic drive to the wheels from the main engine when the rotors are declutched.

Great Britain

EARLY PIONEERS

Although the Farnborough Royal Aircraft Establishment's first attempts at rotary-wing flight with Brennan's helicopters ended in failure, Great Britain was the country where the autogyro, the transitional form between fixed-wing aircraft and the pure helicopter, was investigated in all its forms and variations.

Noteworthy, too, are the efforts made in the rotary-wing field by Denny of Scotland prior to World War I and the small-scale model tests carried out by Travers Ayers in 1913 regarding 'compound' aircraft.

1913 TRAVERS AYERS

Great interest attaches to the small-scale model of a 'hovering aeroplane' built by Travers Ayers in 1913. Inside a tetrapod there was an engine driving two co-axial contra-rotating rotors, one located above, one some distance below, the engine, so that the rotors would provide lift. In addition, a vertical propeller was to be connected with the engine, and thus enable the aircraft to move horizontally. The horizontal rotors could also be declutched, and support was then ensured by the wings, as in a biplane. The four lower ends of the tetrapod were fitted with floats.

1919 BRENNAN

Between 1919 and 1926 building and testing of the Brennan helicopter were carried out at the Royal Aircraft Establishment at Farnborough.

Louis Brennan's aircraft, weighing 3,000 pounds (1,361 kilos), had a large-diameter rotor powered by a 230 h.p. BR 2 rotary engine situated centrally above the pilot and geared to drive airscrews at the tips of the blades.

The first tethered flights took place in 1924 inside a hangar. Free flights started in 1925 and stopped for good in 1926 when a crash put an end to this experimental aircraft's career.

BRISTOL AIRCRAFT COMPANY

Most British pilots in the heroic era of flying were trained on the box kites manufactured by this firm, whose Bristol Fighter made a name for itself in World War I. It was followed by a succession of aircraft of the most vary-

ing types: the Bulldog, the Bombay transport, the Blenheim, the Beaufighter, the Bristol Freighter, the Brabazon and the Britannia.

Besides aircraft, the company also manufactured engines, including some, such as the Hercules, which were sleeve-valved. The Bristol turbojet Olympus powered the Canberra which set up world altitude records in 1953 and 1955.

Bristol's interest in helicopters went back to the autumn of 1944 when the company purchased the patents relating to Raoul Hafner's AR-III gyroplane. Later that year, Hafner himself was appointed chief engineer of the newly created Helicopter Department.

As a result of the consolidation of the British aerospace industry carried out in 1959–60, the Bristol Aircraft Company became part of the British Aircraft Corporation, and the Bristol helicopter division came under the control of Westland, which took over all current construction and maintenance contracts. As a result the Bristol helicopter division's factory at Weston-super-Mare, Somerset, was switched to converting Westland Whirlwinds into HAR Mark 10s and to the service support of Belvederes.

1947 BRISTOL 171 MARK 1

This rotorcraft was powered by an American Pratt and Whitney engine with the crankshaft lying horizontally. Power was transmitted to the rotor's vertical driveshaft by means of a gearbox.

In the rotor head, pitch control was obtained from a three-armed 'spider', of the kind Hafner had previously used for his AR-III jump-start gyroplane. The three rotor blades were made of wood, of which a very strong kind was selected for the leading edge. The same materials were employed for the tail rotor.

Two prototypes were built, and the first flight took place in July 1947.
Engine: Pratt and Whitney R-985, 450 h.p.
Rotor diameter: 47 ft 5 in (14·45 m)
Weight fully loaded: 4,850 lb (2,200 kg)
Cruising speed: 100 m.p.h. (161 k.p.h.)
Inclined climb: 1,000 ft/min (305 m/min)
Absolute ceiling: 14,000 ft (4,267 m)
Range: 230 miles (370 km)
Number of seats: 2

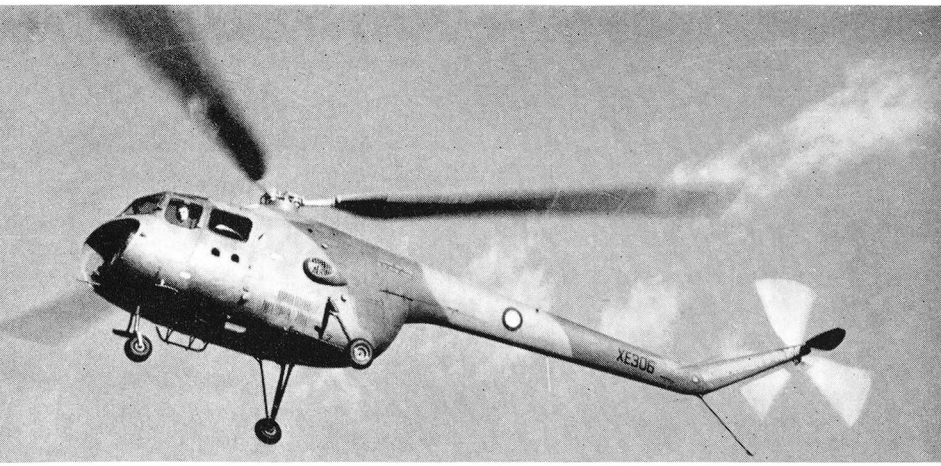
1948 171 MARK 2

As soon as Bristol's had available an engine specially designed for helicopters, they fitted it to the prototype Mark 2. The engine, an Alvis Leonides, was placed horizontally, but its crankshaft ran vertically. This meant eliminating the lower gearbox and a consequent saving in weight. Furthermore, in its new position, the engine was both more accessible and left more room free for passengers and baggage.

Engine: Alvis Leonides L.E. 21 H.M., 550 h.p.
Rotor diameter: 47 ft 5 in (14·45 m)
Weight fully loaded: 5,200 lb (2,359 kg)
Cruising speed: 115 m.p.h. (185 k.p.h.)
Inclined climb: 1,050 ft/min (320 m/min)
Absolute ceiling: 19,000 ft (5,791 m)
Range: 300 miles (483 km)
Number of seats: 5

1949 171 MARK 3 SYCAMORE (HC-10, HR-11 AND HR-12)

The appearance of a new Leonides engine, shorter than the one used in the Mark 2, was the basis of the Mark 3. This resembled its predecessor, but had certain new features such as rearrangement of instruments, the addition of built-in sliding doors and facilities for carrying an additional passenger.



171 MK3 SYCAMORE

The 171 Mark 3A was used by British European Airways for passenger transport. HC-10 and HR-11 are the service designations of the Army versions, and HR-12 designates a model specially designed for rescue work with the Royal Air Force Coastal Command.

Engine: Alvis Leonides 73, 550 h.p.
Length: 46 ft 2 in (14·07 m)
Height: 11 ft 2 in (3·4 m)
Rotor diameter: 48 ft $6\frac{3}{4}$ in (14·81 m)
Weight empty: 3,630 lb (1,647 kg)

Weight fully loaded: 5,200 lb (2,359 kg)
Cruising speed: 93 m.p.h. (150 k.p.h.)
Inclined climb: 1,142 ft/min (348 m/min)
Absolute ceiling: 19,000 ft (5,791 m)
Range: 324 miles (521 km)
Number of seats: 5–6

1950 171 MARK 4 (HR-13, HR-14, HR-50 AND HR-51)

Sometimes known as the 'universal' Sycamore, this rotorcraft had an extended landing gear and a larger baggage compartment at the rear of the fuselage pod. Increased gross weight made it possible to carry an extra 200-pound (90·5-kilo) load should need arise.

All the fitments were provided to make this rotorcraft eminently suitable for civilian use to carry passengers and freight and for the specialized service duties of air ambulance, air search and air-sea rescue work. Detachable clamshell doors facilitated loading. A hydraulic winch attached to the side of the fuselage had its cable hanging directly in front of the door opening and was worked by a hydraulic pump connected to the drive on the main gearbox.

This 'universal' Sycamore has proved its worth under the most diverse weather conditions from the sub-zero conditions of winter in Canada to the humid tropical heat of Malaya.

The following are the various British and Commonwealth service designations: HR-13 in the Royal Air Force Fighter Command; HR-14 in the Royal Air Force; HR-50 and HR-51 in the Royal Australian Navy.

Engine: Alvis Leonides 524/1, 520 h.p.
Length: (blades folded) 46 ft 2 in (14·07 m)
Width: (wheelbase) 8 ft 10 in (2·69 m)
Height: 14 ft 7 in (4·44 m)
Rotor diameter: 48 ft $6\frac{3}{4}$ in (14·81 m)
Weight empty: 4,130 lb (1,873 kg)
Weight fully loaded: 5,400 lb (2,449 kg)
Cruising speed: 92 m.p.h. (148 k.p.h.)
Inclined climb: 1,300 ft/min (396 m/min)
Absolute ceiling: 15,500 ft (4,724 m)
Range: 268 miles (429 km)
Number of seats: 4–5

1951 BRISTOL 173 MARK 1

This, the first British two-engined twin-rotor helicopter, first went on to the drawing-board in 1948 and started its ground tests in May 1951. Besides the two three-bladed contra-rotating rotors set in tandem, this rotorcraft had two interesting features: firstly, its centre of gravity could be displaced; secondly, it could continue to fly on one engine only. The

173 had virtually the same transmission system, rotor assemblies and engine installation as the 171, except that one engine rotated in the opposite direction to the other.

The two rotors could be synchronized by a shaft in conjunction with a gearbox. This shaft was also used in the event of breakdown in one engine to transmit power to the affected rotor from the engine still working. The rear rotor was carried on a pylon forming part of the fixed vertical-fin structure. On each side there was also a tailplane structure set at a marked dihedral angle to increase both longitudinal and lateral stability.

Ground resonance originally caused some trouble. The problem was overcome by linking the right- and left-hand oleo-struts of the undercarriage by small-bore hydraulic piping. The latter formed the two arcs of a circle seen above the upper part of the legs.

Engines (2)*:* Alvis Leonides 73, 550 h.p., giving 1,100 h.p. in all
Length: (overall) 78 ft 2 in (23·83 m)
Rotor diameter: 48 ft 6¾ in (14·81 m)
Weight empty: 7,800 lb (3,538 kg)
Weight fully loaded: 10,600 lb (4,808 kg)
Cruising speed: 85 m.p.h. (137 k.p.h.)
Inclined climb: 1,190 ft/min (363 m/min)
Absolute ceiling: 19,600 ft (5,974 m)
Range: 281 miles (452 km)
Number of seats: 14

1951 173 MARK 2

This version, the second prototype of the 173, had, in addition to various other modifications, the small-bore piping fitted internally, non-castoring rear wheels and castoring front wheels, which, however, could not be steered.

Engines (2)*:* Alvis Leonides 73, 550 h.p., giving 1,100 h.p. in all
Rotor diameter: 48 ft 6¾ in (14·81 m)
Weight fully loaded: 10,600 lb (4,808 kg)
Cruising speed: 85 m.p.h. (137 k.p.h.)
Inclined climb: 1,190 ft/min (363 m/min)
Absolute ceiling: 19,600 ft (5,974 m)
Range: 281 miles (452 km)
Number of seats: 14

1955 173 MARK 3

This version differed radically from its two predecessors by having two four-bladed rotors and a more powerful engine. It was fitted experimentally with front and rear stub wings. The direct development of the 173 Mark 3, the turboshaft Bristol 191, did not fly but the Mark 3 was eventually developed into the Bristol 192.

Engines (2)*:* Alvis Leonides Major, 850 h.p., giving 1,700 h.p. in all
Length: (overall, blades folded) 54 ft $1\frac{7}{10}$ in (16·5 m)
Rotor diameter: 48 ft $6\frac{3}{4}$ in (14·81 m)
Weight fully loaded: 14,500 lb (6,577 kg)
Cruising speed: 138 m.p.h. (222 k.p.h.)
max: 153 m.p.h. (246 k.p.h.)
Inclined climb: 2,000 ft/min (610 m/min)
Absolute ceiling: 16,000 ft (4,876 m)
Range: 182 miles (293 km)
Number of seats: 16

173 MK3

1957 BRISTOL 192 (LATER WESTLAND BELVEDERE 192)

The Bristol 192 is a direct development of the 173 with its twin engines and tandem four-bladed rotors. At the time of its maiden flight on 5 July 1958, it was the largest military helicopter in Western Europe. It was designed to meet various service requirements: troop and freight transport, as an ambulance carrying twelve stretchers, and for supply dropping. The cabin length of 24 feet (7·32 metres) with a wide centre of gravity range makes possible many variations in use.

For twin-engine operation, it is powered by two Napier Gazelle Series 2 gas-turbine engines with the power output of each limited to 920 s.h.p. In single-engine operation safety is ensured by a synchronizing shaft which interconnects the two engines and enables both rotors to be driven by one engine in case of emergency.

The four-wheel undercarriage is strong enough to absorb the shock of emergency landing.

The 192 itself is in use in the RAF, while a civil version, the 192C, was developed, to carry twenty-four passengers.

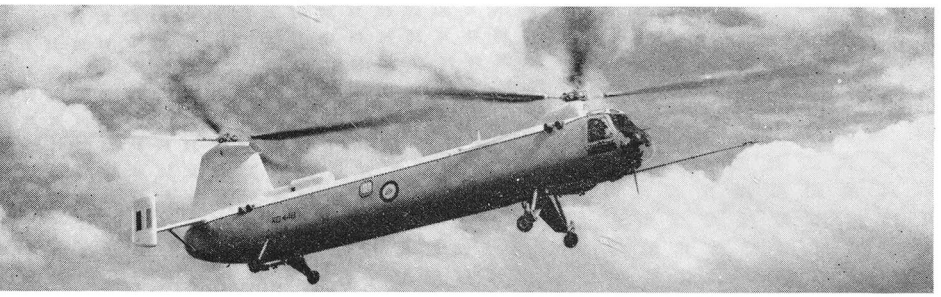
Westland re-christened the Bristol 192 as the Belvedere. Production of this aircraft is at present discontinued.

On 30 May 1961, in a Belvedere 192, C. T. D. Hosegood flew from London to Paris in 1 hour 41 minutes 28 seconds, and on 2 June 1961 from Paris to London in 1 hour 40 minutes 55 seconds. This is equivalent to a London-to-Paris speed of 125·72 m.p.h. (202·42 k.p.h.) and a Paris-to-London speed of 126·46 m.p.h. (203·52 k.p.h.).

Engines (2)*:* Napier Gazelle Series 2, each of 1,650 s.h.p., derated to 920 s.h.p.

Length: 54 ft $3\frac{1}{10}$ in (16·54 m)

Length: (cabin) 5 ft $3\frac{1}{4}$ in (1·6 m)



BRISTOL 192

WESTLAND BELVEDERE

Height: 17 ft (5·18 m)
Rotor diameter: 48 ft 8 in (14·86 m)
Weight empty: 10,723 lb (4,863 kg)
Weight fully loaded: 18,000 lb (8,164 kg)
Inclined climb: 1,175 ft/min (358 m/min)
Service ceiling: 13,250 ft (4,038 m)
Range: 420 nautical miles (778 km)
Number of seats: 20

BRITISH AIRCRAFT MANUFACTURING COMPANY

Since an autogyro could be used from the deck of a ship, the British Admiralty ordered five of them for the Fleet Air Arm from the Cierva Company.

The British Aircraft Manufacturing Company of Hanworth carried out the order for these side-by-side two-seaters, the last of which was delivered shortly after the outbreak of World War II.

1938 C-40

This autogyro had a three-bladed rotor designed by Dr J. A. J. Bennett, who was later to become head of the Fairey helicopter branch.

The C-40 first flew in 1938; the first delivery to the Royal Navy took place in 1939.

Engine: Salmson 9 NG, 180 h.p.
Rotor diameter: 40 ft (12·19 m)
Cruising speed: (max) 105 m.p.h. (169 k.p.h.)
Number of seats: 2

CAMPBELL

Campbell Aircraft Limited is the sole licensed manufacturer in the United Kingdom of American Bensen Gyro-Gliders and Gyro-Copters. More specifically, the firm has worked in close co-operation with Schermuly Ltd to develop a blade-tip rocket motor to spin-up the rotor. The Schermuly rockets are solid and, when electrically ignited, speed up the Bensen rotor to 200 r.p.m.

CIERVA

The Cierva Autogiro Company Ltd was founded in March 1926 to hold the patents taken out by Juan de la Cierva and to grant licenses for the

construction of autogiros. A total of some 500 were eventually built throughout the world. 'Autogiro' is a registered trade name.

In the United Kingdom the following firms held licences from the Cierva Autogiro Company Ltd to manufacture the models listed:

Airwork: C-30
British Aircraft Manufacturing Company: C-40
Comper: C-25
De Havilland: C-24
National Flying Services: C-30P
Parnall: C-10, C-11
A. V. Roe: C-6C, C-6D, C-8R, C-8V, C-8L-I, C-8L-II, C-8L-III, C-8 Mk. IV, C-9, C-12, C-17 Mk. I, C-17 Mk. II, C-19 Mk.I, C-19 Mk. II, C-19 Mk. III, C-19 Mk. IV, C-19 Mk. V, C-30P, C-30A, C-30 Mk. III
Short Brothers: Short 31/26
G. & J. Weir: W-1, W-2, W-3, W-4
Westland: C-29, CL-20

Outstanding among the autogiros designed directly by the company were the C-19, the C-30 and several variants, and also Bennett's C-40.

In the middle of 1940 the company became dormant and was not revived until 1943, when C. G. Pullin of G. & J. Weir was managing director. In actual fact the Cierva Company took over the rotary-wing activities of G. & J. Weir Ltd (*q.v.*) which had built the first practical helicopter in the United Kingdom.

The Cierva Autogiro Company then produced several helicopters, one with jet torque compensation at the tail, and two others, each at opposite extremes in size: the Air Horse, the largest helicopter of its day, and the small two-seater Skeeter.

The accident which occurred to the W-11 Air Horse put an end to the company's work in the large-helicopter field, and its work was taken over in January 1951 by Saunders-Roe Ltd (*q.v.*), who revived the W-11 and continued work on the Skeeter.

1938 S-22/38 (PROJECT)

This project, conceived shortly before the outbreak of World War II by J. A. J. Bennett, was for a gyrodyne, combining the features of a helicopter and an autogyro, since it was to have an airscrew and one three-bladed rotor.

The planned power source for this two- or three-seater rotorcraft was a Rolls-Royce 600 h.p. Kestrel engine.

Engine: Rolls-Royce Kestrel, 600 h.p.
Number of seats: 2–3

1944 W-9

This experimental design had a three-bladed rotor and torque was compensated for by a jet-thrust arrangement at the end of the fuselage. The air from a multi-bladed fan which cooled the engine was ducted through the inside of the fuselage, heated by the exhaust gases and then ejected through an opening on the port side. Two horizontal shutters controlled the flow of this air. The controllable efflux was also used to impart turning movements to the rotorcraft, which had neither fin nor rudder. The multi-bladed variable-pitch fan was coupled to the rudder pedals and thus provided yaw control.

Engine: Gipsy VI Series 2, 205 h.p.
Rotor diameter: 36 ft (10·97 m)
Weight fully loaded: 2,647 lb (1,200 kg)
Number of seats: 2

W-9

1948 W-11 AIR HORSE

In this helicopter, power from a single engine was transmitted through shafting to three-bladed rotors mounted on outriggers, each at the tip of a triangle. All three turned in the same direction, but their plane of rotation was sufficiently tilted to compensate for torque. Each rotor hub had a control 'spider' which ensured cyclic and collective pitch control.

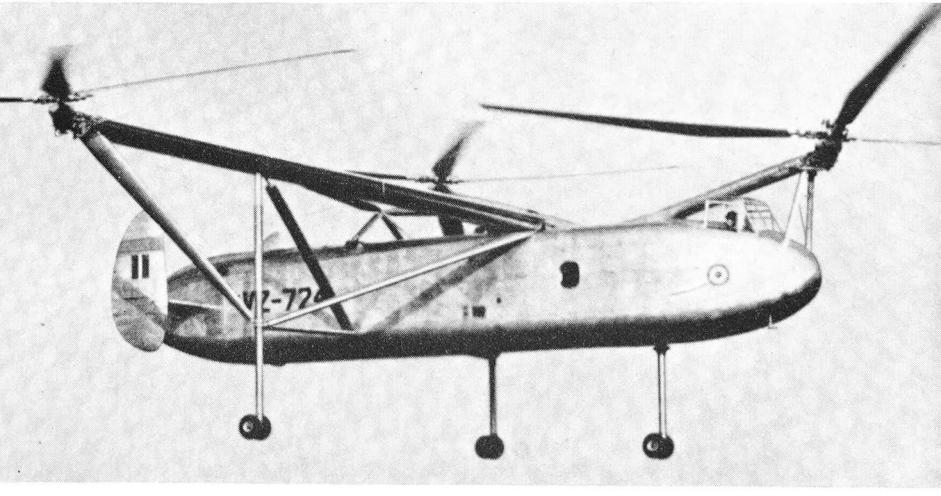
The engine with its distribution gearbox to drive the rotors was situated just behind the cockpit in the fuselage.

The fuselage was designed to carry twenty-four passengers in a compartment measuring 19 feet by 7 feet 7 inches by 5 feet 9 inches (5·79 by 2·31 by 1·77 metres).

There was a tricycle landing gear, each leg of which was fitted with an oleo-pneumatic shock-absorber.

The prototype, the largest in the world at that date, made its maiden flight in December 1948, but shortly after being displayed at the Farnborough Show it crashed, and work did not start on it again until the Cierva Company, as previously stated, was taken over by Saunders-Roe.

Engine: Rolls-Royce Merlin 24, 1,620 h.p.
Length: (including blades) 88 ft 7 in (27 m)
Width: (including blades) 95 ft (28·96 m)
Height: 17 ft 9 in (5·41 m)
Rotor diameter: 47 ft (14·32 m)
Weight empty: 12,140 lb (5,505 kg)
Weight fully loaded: 17,500 lb (7,937 kg)
Cruising speed: 110 m.p.h. (177 k.p.h.)
Inclined climb: 1,210 ft/min (369 m/min)
Absolute ceiling: 28,000 ft (8,534 m)
Range: 330 miles (531 km)
Number of seats: 26



W-11

1948 W-11T (PROJECT)

This project was for an enlarged version of the W-11 which was to have two engines.

Engines (2)*:* Rolls-Royce Merlin 502, 1,620 h.p.
Rotor diameter: 54 ft (16·46 m)
Weight fully loaded: 25,000 lb (11,340 kg)

Cruising speed: 120 m.p.h. (193 k.p.h.)
Inclined climb: 2,330 ft/min (710 m/min)
Absolute ceiling: 31,500 ft (9,600 m)
Range: 440 miles (708 km)

1947 SKEETER 1

The main objective in designing this helicopter was to keep production costs to the minimum. Apart from extreme simplicity, apparent in the welded tubular construction, the configuration was conventional: one main, and one anti-torque tail rotor.

The main use was to be for training helicopter pilots, though some military applications were also considered.

The maiden flight took place in October 1948.

Engine: Jamieson, 106 h.p.
Length: 26 ft 8 in (8·13 m)
Height: 7 ft 10 in (2·39 m)
Rotor diameter: 29 ft (8·84 m)
Weight empty: 810 lb (367 kg)
Weight fully loaded: 1,210 lb (549 kg)
Cruising speed: 75 m.p.h. (121 k.p.h.)
Inclined climb: 900 ft/min (274 m/min)
Absolute ceiling: 10,000 ft (3,048 m)
Range: 130 miles (209 km)
Number of seats: 2

1949 SKEETER 2

The second version resembled the first, but was of larger size with a more powerful engine and a redesigned fuselage in conventional sheet design.

The first flight took place in October 1949, but the prototype eventually broke up during ground running because of resonance trouble.

Engine: Gipsy Major 10, 145 h.p.
Length: 28 ft 5 in (8·66 m)
Height: 10 ft (3·05 m)
Rotor diameter: 32 ft (9·75 m)
Weight empty: 1,200 lb (544 kg)
Weight fully loaded: 1,800 lb (816 kg)
Cruising speed: 80 m.p.h. (129 k.p.h.)
max: 95 m.p.h. (153 k.p.h.)
Inclined climb: 1,000 ft/min (305 m/min)
Absolute ceiling: 14,250 ft (4,343 m)
Range: 185 miles (298 km)
Number of seats: 2

1950 SKEETER 3

Two prototypes were built of this version, which followed the same general lines as the earlier ones, but the engine initially used (and listed below) was subsequently replaced by the more powerful 180 h.p. Blackburn Bombardier.

Engine: Gipsy Major 10, 145 h.p.
Length: 31 ft 2 in (9·5 m)
Height: 9 ft 10 in (3 m)
Rotor diameter: 32 ft (9·75 m)
Weight fully loaded: 2,000 lb (907 kg)
Cruising speed: 80 m.p.h. (129 k.p.h.)
Inclined climb: 1,260 ft/min (384 m/min)
Absolute ceiling: 17,300 ft (5,273 m)
Range: 290 miles (467 km)
Number of seats: 2

COMPER

In the early 1930s a Comper aircraft, the Swift, was well known for its performances at aerobatic demonstrations and for its successes in races at which it competed both in the United Kingdom and abroad.

Nick Comper produced aircraft other than the Swift, among them the Comper Mouse, the Comper Streak, etc.

In 1932 Comper Aircraft started to build an autogyro at its Heston works, under licence from La Cierva.

1932 C-25 (COMPER G-31/1)

This small single-seater, built round a Swift fuselage, had an 85 h.p. engine, also a three-bladed rotor with flapping and drag hinges, and mechanical-drive starting. The rotor mast was streamlined.

Tests were started early in 1933, but the design was abandoned when the blades broke during a demonstration at Heston.

Engine: Pobjoy R, 85 h.p.
Number of seats: 1

DE HAVILLAND

The De Havilland Aircraft Company was founded in September 1920. It first adapted the DH 4 day bomber into an aircraft to carry two passengers. In 1925 it brought out the Moth and in 1927 the Gipsy I engine, the first of a long line of these power sources for light aircraft.

Perhaps the best known of the company's later products were the Albatross, the Flamingo and the Mosquito and, in the era following World War II, the Vampire and Sea Venom. In the civil-aviation field were the Dove, the Heron, the Comet with four jet engines, and the Ambassador. However, De Havilland has constructed only one rotorcraft, the Cierva C-24, which goes back as far as 1931.

1931 C-24

This autogyro, built at Stag Lane aerodrome, had a cabin with two seats one behind the other. A De Havilland engine powered a C-19 Mark IV three-bladed rotor, and there was a tricycle undercarriage.

The C-24 made its maiden flight in September 1931. It was very much in the news from 27 May to 9 June 1932, when, with a modified tail, it was used by La Cierva for a tour of Europe, covering 1,430 miles (2,300 kilometres).

Engine: De Havilland Gipsy III, 120 h.p.
Rotor diameter: 34 ft (10·36 m)
Weight fully loaded: 1,800 lb (816 kg)
Cruising speed: (max) 115 m.p.h. (185 k.p.h.)
Number of seats: 2

FAIREY

Charles Richard Fairey, who died on 30 September 1956, started as chief engineer at Short Brothers, and in 1915 founded the Fairey Aviation Company. From its earliest days the company has built almost exclusively service, and in the main naval, aircraft. One commercial aircraft, a four-engined transport, was planned, but its construction had to be abandoned because of the outbreak of World War II. During that war Fairey built such well-known aircraft as the Swordfish, Albacore, Fulmar, Barracuda and Firefly.

Since the end of World War II, Fairey's main output has been the Gannet, a twin-propeller turbine anti-submarine aircraft; it has also developed delta-wing research models such as the FD-1 and the FD-2, which set up a world speed record with a speed considerably exceeding 1,000 m.p.h. (1,610 k.p.h.). Development work has also been done on a certain number of guided missiles.

Fairey's entry into the rotary-wing field dates from June 1945, when a helicopter branch was set up with J. A. J. Bennett as chief technician. At about this time the company also acquired rights in the first jet helicopter designed by the Austrian, Doblhoff. Several rotorcraft were built, the firm showing a marked preference for the 'convertible' type, in which translational thrust is obtained by means other than through the main rotor

blades and where stub wings provide part of the lift. In 1960, as part of the consolidation of the British aircraft industry, Fairey Aviation was merged with Westland.

1947 GYRODYNE

Two experimental prototypes were built of this rotorcraft, the idea underlying the design being to place one rotor, normally at the tail, on the side. It thus became a two-bladed tractor airscrew on the starboard wing tip. The resultant traction reduced the work required from the main rotor.

The power supplied by a conventional, horizontal-crankshaft engine was transmitted in such a way that during translational flight the greater part was delivered to the airscrew. This, in conjunction with the lift given by the stub wings, greatly assisted the three-bladed rotor, and high cruising speeds became possible.

Bennett, who was long associated with La Cierva's work, retained the tilting autogyro head for this Gyrodyne.

At the front of the steel-tube fuselage there was accommodation for two crew members, and behind it a bench seat for three passengers.

The first flight took place in December 1947, and later, piloted by Arkell, the Gyrodyne set up a helicopter world speed record (see under World Records).

One prototype was destroyed as the result of an accident; the other was converted into the Jet Gyrodyne to investigate the problems connected with tip-jet propulsion (see below).

Engine: Alvis Leonides, 525 h.p.
Length: 25 ft (7·62 m)
Height: 10 ft (3·05 m)

GYRODYNE

Rotor diameter: 51 ft 7½ in (15·72 m)
Weight empty: 3,600 lb (1,633 kg)
Weight fully loaded: 4,800 lb (2,177 kg)
Cruising speed: 110 m.p.h. (177 k.p.h.)
Inclined climb: 1,300 ft/min (396 m/min)
Absolute ceiling: 10,000 ft (3,048 m)
Range: 250 miles (402 km)
Number of seats: 4–5

1954 JET GYRODYNE

This was one of the two 1947 Gyrodyne prototypes modified to work on the principle of tip-jet propulsion.

The Gyrodyne's original three-bladed rotor was replaced by a large two-bladed rotor with Fairey pressure jets at the tip of each blade. Air, supplied from a compressor powered by an Alvis engine, passed through the hollow blades to the tips, where it was mixed with fuel and burnt.

The pressure-jet system was used for take-off, landing and hovering; in horizontal flight the engine's power was transferred to airscrews at the tip of each of the stub wings.

The Jet Gyrodyne, the first British rotorcraft to employ this type of power, started its successful flying career in the first half of 1954 and also served as a test bed for trials of the system embodied in the Rotodyne.

Engine: Alvis Leonides, 525 h.p.
Number of seats: 2

JET GYRODYNE

1953 ROTODYNE

This experimental compound helicopter was powered by two Napier Eland turboprop engines located in special housing below the fixed wing. Each of the engines drove a tractor airscrew and an auxiliary compressor, operated through a hydraulic clutch and used to feed the tip-mounted pressure jets.

At take-off and landing the compressors were engaged and supplied air to the four-bladed rotor. This ducted air was mixed with fuel and on combustion at the blade tips supplied the power needed for flight as a helicopter. The airscrews then took up only sufficient power to ensure yaw control.

In horizontal flight the compressors were declutched and the turboprop's power was entirely transferred to the airscrews. The rotor then turned by auto-rotation and provided some of the lift, the rest of which was ensured by the fixed wing.

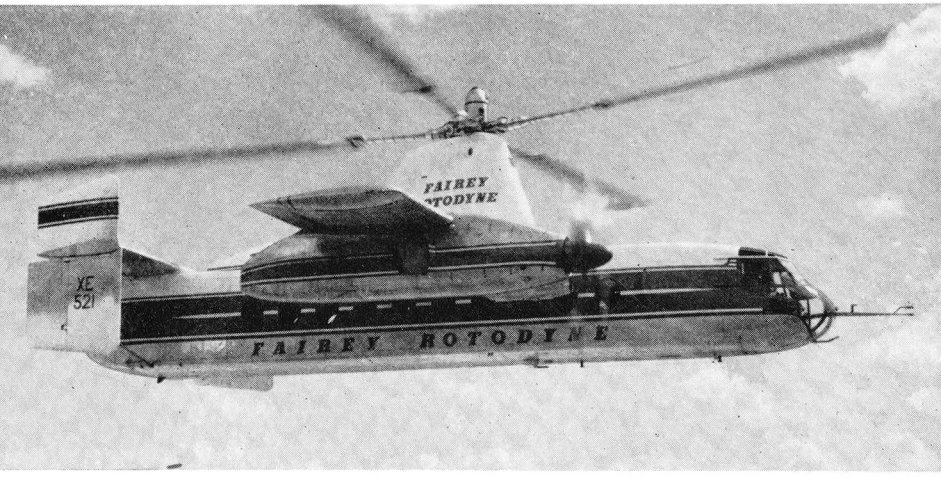
Conventional control surfaces were used on the Rotodyne.

Two prototypes of this rotorcraft were designed to challenge medium twin-engine fixed-wing transport aircraft, by offering a capacity of 3,300 cubic feet (almost 94 cubic metres), so that forty passengers and their baggage could be carried. Furthermore, because of the unrestricted space inside the fuselage, big enough for a payload exceeding 11,000 pounds (5,000 kilos), numerous military and civil applications could be foreseen.

The Rotodyne first flew on 6 November 1957 and performed its first complete transition and flight in auto-rotation on 1 April 1958.

It was planned as a VTOL aircraft to ply between large urban centres. The production model was planned to be powered by Rolls-Royce Tyne turboprop engines. Tentative orders were placed by BEA and also by New York Airways. In addition an agreement was reached between Fairey and Kaman for the sale of the Rotodyne and possibly even for its manufacture in the United States.

When Westland absorbed Fairey in 1960 it continued its work on the



ROTODYNE

Rotodyne. However, despite the interest aroused by the possibility of both civil and military applications, the Rotodyne was abandoned when on 26 February 1962 the Ministry of Aviation terminated its support for it.

Engines (2): Napier Eland E-151 turboprop, 3,300 b.h.p.
Length: 58 ft 8 in (17·88 m)
Width: (wing span) 46 ft 6 in (14·17 m)
Height: 22 ft 2 in (6·76 m)
Rotor diameter: 90 ft (27·43 m)
Weight empty: 24,000 lb (10,886 kg)
Weight fully loaded: 33,000 lb (14,968 kg)
Cruising speed: 150 m.p.h. (241 k.p.h.)
Range: 210 miles (338 km)
Number of seats: 42

1955 ULTRA-LIGHT

This light two-seater pressure-jet helicopter was built to meet two particular British Army requirements: air observation and so-called 'air runabout' duties.

The engine is a French Turboméca Palouste gas-turbine re-engineered by Blackburn-Turboméca and General Aircraft Ltd, with the turbine in Nimonic 90 alloy.

Air from an oversize centrifugal compressor arrives at the blade tips, where it is joined by fuel from the same tank as that supplying the gas-turbine and carried by centrifugal force to the sparking-plugs, which produce ignition of the mixture in the small combustion chambers.

The controls used are of the direct tilting-head-type.

The pilot's seat is on the right; from the seat on the left, the passenger has a clear view forwards and backwards.

In September 1956 the helicopter, which can be transported on a three-ton lorry, was exhibited at the Farnborough Air Show and made some inclined climbs at approximately 22 feet (6·7 metres) per second, and some auto-rotation descents at about 65 feet (19·8 metres) per second.

The Ultra-Light comes into the same class of helicopter as the Djinn built by SNCASO (*q.v.*) in France.

Engine: Blackburn Palouste, 256 h.p.
Length: 14 ft (4·27 m)
Height: 7 ft 11 in (2·41 m)
Width: 7 ft 11 in (2·41 m)
Rotor diameter: 28 ft 3 in (8·61 m)
Number of seats: 2

ULTRA-LIGHT

FIRTH HELICOPTERS LTD

In 1951 this firm, which has now ceased to operate, started to build a prototype helicopter using a rotor system based on American patents held by Landgraf (see Landgraf, under United States of America).

1952 FH-1

This helicopter was built round the fuselage of the unorthodox 1948 aircraft 'Planet Satellite'. The latter was small, of monocoque construction in an extremely light magnesium-zirconium alloy, and fitted at the end of its tail with a pusher airscrew driven by an engine through an extension shaft.

The FH-1 had two three-bladed, non-articulated-type rotors, mounted on outriggers and based on Landgraf patents. There was a tricycle landing gear.

This helicopter was abandoned before it ever flew because of financial

and technical difficulties, the latter mainly connected with the forepart, which proved excessively heavy.

Engine: Gipsy Major X, 145 h.p.

Number of seats: 2

HAFNER

As early as 1929 in collaboration with Nagler (see under Austria) Raoul Hafner began building small single-seater helicopters, the R-1 and R-2, at Aspern airfield near Vienna.

These helicopters were subsequently tested in the United Kingdom, and there Hafner stayed. Because of the difficulties at that time in designing an airworthy helicopter, Hafner set about developing a gyroplane, and actually built one working on a cyclic pitch control which gave good performance.

During World War II he did much development work, principally on the Rotaplane (*q.v.* in this chapter) and finally in 1944 he joined the Bristol Aircraft Company.

1937 AR-III

Starting in 1937, numerous flights were made in the United Kingdom by this rotorcraft, which was a rebuild of a prototype seriously damaged during its trials the previous year.

At a conference held in Philadelphia, Hafner explained the difference between the La Cierva system and his own as follows: 'The fundamental difference between the two rotors lies in the fact that the hub of the Hafner rotor rotates about a rigid axle through which all the flying loads are carried direct to the fuselage, while the variation of incidence is achieved by separate control linkage which enables the rotor to be controlled with small efforts on the control column.'

The hub embodied a 'spider', the three claws of which were attached to the blade control levers. The 'spider', since incorporated into all the Bristol helicopters, was fitted with a central axle running through the hollow interior of the rotor shaft and connected to the pilot's stick by a system of ball joints and levers, so that it could ensure differential pitch in the blades.

This, together with the collective and cyclic pitch control the gyroplane possessed, enabled it to do everything which La Cierva did by means of the tilting head in his designs. The Hafner autogyro could also land on the spot, thanks to its collective pitch control, through which the pilot could utilize all the rotor's kinetic energy.

The gyroplane had no fixed wing, but it did have a conventional rudder

and its tailplane was designed to counteract torque. The fuselage was of welded steel tubes.

Engine: Pobjoy Niagara III, 84 h.p.
Rotor diameter: 33 ft (10·06 m)
Weight empty: 640 lb (290 kg)
Weight fully loaded: 890 lb (404 kg)
Cruising speed: 98·5 m.p.h. (158·5 k.p.h.)
max: 115 m.p.h. (185 k.p.h.)
Number of seats: 1

1940 EA-115 (PROJECT)

This project, the conclusion of which was stopped by World War II, was for a helicopter with one three-bladed rotor, the torque of which was to be compensated for by its own downwash. The fuselage had the shape of a twisted aerofoil to counteract the torque from the rotor's high rotational speed.

Engine: Pobjoy Niagara
Length: 38 ft 9 in (11·81 m)
Height: 10 ft 10 in (3·3 m)
Number of seats: 1

HOPPICOPTERS LTD

Early in 1949 Horace Pentecost, an American constructor of single-seater helicopters, visited Britain at the invitation of the British Ministry of Supply to demonstrate two of his Model 104 aircraft.

In order to carry out the necessary development work and modifications a new company, Hoppicopters Ltd, was founded in Hampshire.

1949 HOPPICOPTER MARK II

As modified for British requirements, this helicopter's engine was located not behind the pilot's shoulders but under his seat. The fuel tank, on the other hand, was placed behind him.

The parallel twin engine had been modified by Hoppicopters Ltd for this specific purpose: the contra-rotating rotors were of the same size as on the original model except for a one-inch increase in the chord.

Engine: Triumph, 40 h.p. (modified)
Rotor diameter: 17 ft (5·18 m)
Weight empty: 146 lb (66 kg)
Weight fully loaded: 300 lb (136 kg)
Cruising speed: 60 m.p.h. (97 k.p.h.)
Inclined climb: 200 ft/min (61 m/min)
Range: 70 miles (113 km)
Number of seats: 1

HUNTING PERCIVAL

Since 1936 a long succession of light aircraft has been turned out by the Percival plant at Luton: sporting, touring and training aircraft, the best known of which are the Gull, Mew Gull and the Proctor.

In 1944 the Percival firm was taken over by Hunting & Son, and later traded under the title of Hunting Percival Aircraft Ltd. The firm's more recent development work has covered not only light-transport aircraft such as the Pembroke and the two-seater jet trainer, the Provost, but also the first types of helicopter using the Napier Oryx gas-generator.

1952 P-74

Preliminary work started in 1950 on this design, which uses the whole output of its two gas-turbines with pipes extending to the very tips of the blades.

The Napier Oryx gas-producer used works on a low-pressure, low-temperature gas system. One feature of it is that an auxiliary compressor, with its own air intake and driven by the common turbine, mixes relatively cold air with the exhaust gases, the flow of which is thereby increased and cooled. The flow is led through three stainless steel ducts, each about 4 inches (10 centimetres) in diameter.

The three-bladed rotor is of the tilting type; its non-feathering blades are fitted with ailerons on the trailing edges so that variation of pitch may be obtained. Collective pitch is obtained by means of a screw-jack. During developmental work, trials were made on the rotor blades in a test tower, where a Derwent turbojet engine supplied the necessary gas flow.

The fuselage is of conventional design and has a four-wheeled under-carriage.

P-74

The main purpose of this project was to produce a test model for the P-105, a general-purpose helicopter.

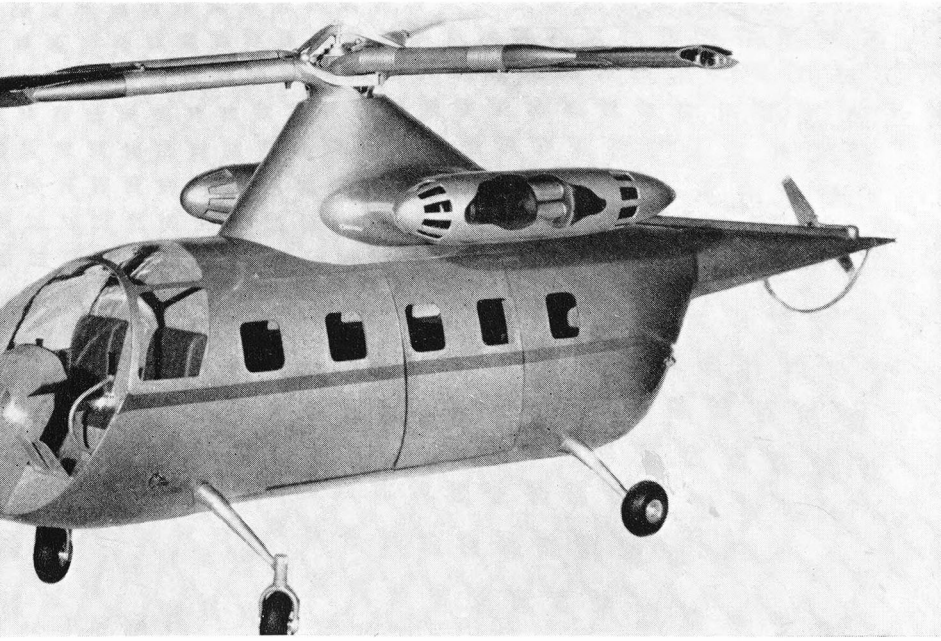
Engines (2)*:* Napier Oryx Nor.1, 754 s.h.p.
Rotor diameter: 55 ft (16·76 m)
Weight fully loaded: 7,750 lb (3,515 kg)
Cruising speed: 110 m.p.h. (177 k.p.h.)
Inclined climb: 1,210 ft/min (369 m/min)
Absolute ceiling: 28,000 ft (8,534 m)
Range: 330 miles (531 km)
Number of seats: 10

1954 P-105 (PROJECT)

This project was based on the same drive system as that tested on the P-74.

The two gas-generators were housed in outrigger nacelles with the compressor intake at the rear. Connected to them were the gas ducts, running right to the tip of the blade, at the root of which the ducts were flexible to allow for blade flapping and feathering as well as for hub-tilt freedom.

Beneath the compact rotor and gas-generator-unit assembly was the



P-105

fuselage, designed in light alloy with large sliding doors so that, if necessary, freight could be loaded directly into the cabin. The latter's cubic capacity of 308 cubic feet (just under 9 cubic metres) was large enough for ten passengers.

The arrangement whereby the fuselage was suspended beneath the rotor–gas-generator-unit assembly made provision for an aerial crane version in which quite a large part of the fuselage would be replaced by the crane mechanism right up to the height of the rotor shaft.

The landing gear was to consist of four wheels, the front set of which was to be castoring.

Engines (2)*:* Napier Oryx gas-generator
Length: (blades folded) 44 ft (13·41 m)
Width: (blades folded) 11 ft 3 in (3·43 m)
Height: 14 ft 3 in (4·34 m)
Rotor diameter: 63 ft (19·2 m)
Weight fully loaded: 10,000 lb (4,535 kg)
Range: 180 miles (290 km)
Number of seats: 12

KAY

Towards the end of 1934, Oddie Bradbury & Cull Ltd, a firm which supplied rotor blades to the Cierva Company, built an autogyro to specifications which David Kay, a Scot, had as far back as 1927 shown to La Cierva himself, and a little later to the Weir Company and to the Air Ministry.

Kay's idea was a system of collective pitch control combined with a tilting rotor head.

Kay's gyroplane was one of the exhibits at the Farnborough Fiftieth Anniversary Display in 1954.

1934 KAY

Development work was done by Kay on two autogyros known as the 32/1 and 33/1.

In Kay's single-seater 'direct-control'-type autogyro the four-bladed rotor was mounted on a pylon. Positive control of lift was obtained by varying the incidence of the blades. In point of fact, Kay's system was a practical application of the collective pitch control found on helicopters today. Longitudinal control was provided by a hinged tailplane and elevators.

The 33/1 version flew regularly from 1935.

Engine: Pobjoy, 75 h.p.
Length: 17 ft 11 in (5·46 m)

Height: 7 ft 8 in (2·34 m)
Rotor diameter: 22 ft (6·71 m)
Weight empty: 838 lb (380 kg)
Weight fully loaded: 1,102 lb (500 kg)
Number of seats: 1

McCANDLESS

In Northern Ireland, Rex McCandless, together with Frank Robertson of Short Brothers & Harland, has developed a small autogyro which he hopes to produce in moderate quantities.

1964 A-2

This prototype autogyro, which made its maiden flight in 1966, is a small single-seater machine. It was originally powered by a Triumph 36 h.p. engine which was replaced in 1965 by a Volkswagen 1500 c.c.
Engine: Volkswagen, 60 h.p.
Rotor diameter: 22 ft (6·71 m)
Weight fully loaded: 520 lb (236 kg)
Cruising speed: 70 m.p.h. (113 k.p.h.)
max: 95 m.p.h. (153 k.p.h.)
Range: 120 miles (193 km)
Number of seats: 1

JOHN MURRAY

In 1952 John Murray, a motor-repair man, started to design a home-made helicopter. The Air Ministry gave him permission to fly it to a height of 10 feet (3·05 metres), provided the rotorcraft, which had not been built under Air Registration supervision, was tethered to the ground.

1954 MURRAY

This 'amateur' helicopter was a single-seater consisting of a tubular chassis with three wheels at the end of tubes starting from the main tubular structure which forms the pilot's seat and carries the engine.

There were two co-axial contra-rotating two-bladed rotors controlled by a hanging stick.

PARNALL

George Parnall and Company produced light aircraft, one of the best-

known of which was the Parasol research monoplane. In 1935 the firm's name was changed to Parnall Aircraft Ltd, and it then became engaged exclusively on the production of equipment and armament for the Royal Air Force.

In the years 1927 and 1928 Parnall built two autogyros under licence from La Cierva.

1927 C-10

This single-seater autogyro had a fixed head, stub wings, rudder and elevator. It crashed during flight at Yate, Glos.

Engine: Genet I, 70 h.p.

Number of seats: 1

1928 C-11

The second autogyro built by Parnall had a more powerful engine than the first, but the same system of starting the rotor with a rope. This prototype also crashed during its first tests.

Engine: A.D.C. Airdisco, 120 h.p.

A. V. ROE

This company first became indirectly connected with rotorcraft when the fuselage of one of its aircraft was used by the Spanish pioneer, La Cierva (*q.v.*) for the C6-A autogiro brought to England in 1925 for demonstration purposes. This fuselage, also used later on certain other autogyros, was that of an Avro 504K trainer widely used in World War I.

During the inter-war period, the company expanded considerably: no less than 11,000 of its versatile Ansons were built. In World War II the Avro Lancaster proved a very effective heavy bomber. The Shackleton, used by the Royal Air Force Coastal Command, made its first flight in the same year as the 707 delta-wing research aircraft, from which was developed the Vulcan, the world's first operational delta-wing bomber. A. V. Roe is now a member of the Hawker Siddeley group.

1926 C-6C (AVRO 574)

La Cierva's sixth autogiro, the C-6A, was completed in 1924 and brought by him from Spain to England in the summer of 1925 for demonstrations given in October of the same year. These were so successful that the Air Ministry ordered two identical machines from A. V. Roe.

Known in its British version as the Avro 574, the single-seater C-6C, built round an Avro 504K fuselage, had a different engine from the original. The four rectangular blades of the rotor, which was of the fixed-head type, were fitted with flapping hinges. This, the first autogiro to be built in the United Kingdom, was exhibited at the Hendon Air Pageant.

The second version had stub wings aimed at unloading the rotor. In the course of trials held early in 1927 one of the rotor blades broke. The subsequent inquiry attributed the accident to the rigidity of the blades in their rotational plane.

Engine: Clerget 9 Bb, 130 h.p.
Rotor diameter: 36 ft (10·97 m)
Weight fully loaded: 1,100 lb (500 kg)
Number of seats: 1

1926 C-6D (AVRO 575)

This autogiro resembled the C-6C, except that it had two seats instead of its predecessor's one. On 30 July 1926, one day after the first flight, it flew again with La Cierva on board. La Cierva thus became the first man to fly as a passenger in an autogiro. In September 1926 the well-known German air expert, Ernst Udet, also flew as a passenger on this aircraft during a demonstration given at Berlin's Tempelhof airport.

Engine: Clerget 9 Bb, 130 h.p.
Rotor diameter: 36 ft (10·97 m)
Number of seats: 2

1927 C-8R (AVRO 587)

This rebuilt version of the C-6D had a new rotor of greater diameter, with four paddle-shaped blades and flapping and drag hinges. Another model was tested with a two-bladed rotor, but in flight it proved extremely unstable.

Engine: Clerget 9 Bb, 130 h.p.
Rotor diameter: 39 ft 7 in (12·06 m)
Number of seats: 2

1927 C-8V (AVRO 586)

This prototype differed only from the C-8R in being powered not by a rotary Clerget but by a more powerful water-cooled Wolseley Viper engine.

Engine: Wolseley Viper, 200 h.p.
Rotary diameter: 39 ft 7 in (12·06 m)
Number of seats: 2

1927 C-8L-I (AVRO 611)

In September 1927 this aircraft made the first autogiro cross-country flight in England by flying from Farnborough to Hamble. Built round an Avro 504N fuselage, it had a four-bladed rotor, dual controls, stub wings and an undercarriage with a wider track than its predecessors.

Engine: Lynx, 180 h.p.
Rotor diameter: 39 ft 7 in (12·06 m)
Number of seats: 2

1928 C-8L-II AND III (AVRO 617)

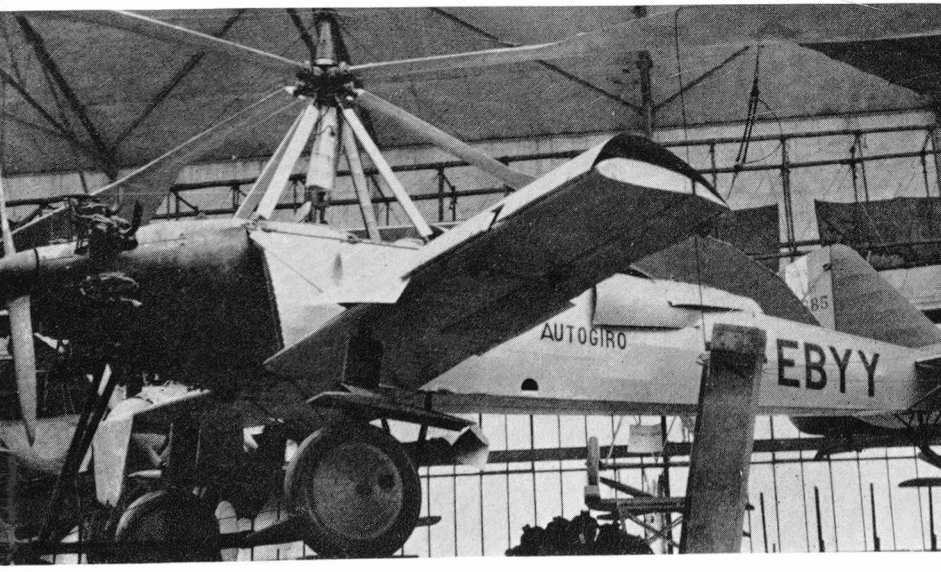
This autogiro, a civil aircraft version of the C-8L-I, was also built round an Avro 504N fuselage, with a wide undercarriage. The rotor was entirely free round its axis, but its four blades were joined by cables to prevent excessive dragging in the plane of rotation, while centrifugal force controlled flapping in the vertical plane.

The fixed wing was fitted with conventional ailerons to control the aircraft laterally in horizontal flight.

On 18 September 1928 a C-8L-II made the first autogiro cross-Channel flight by flying at about 4,000 feet from Croydon, near London, to Le Bourget, on the outskirts of Paris. This aircraft is now in the French Museum of the Air.

An identical aircraft was made, also in 1928, by A. V. Roe under the designation of C-8L-III for delivery to Italy.

Engine: Armstrong Siddeley Lynx, 180 h.p.
Length: 36 ft (10·97 m)
Height: 14 ft 9 in (4·5 m)
Rotor diameter: 39 ft 7 in (12·06 m)
Weight empty: 1,750 lb (794 kg)
Weight fully loaded: 2,240 lb (1,100 kg)
Cruising speed: min: 20 m.p.h. (32 k.p.h.)
max: 100 m.p.h. (161 k.p.h.)



C-8L-II

Inclined climb: 645 ft/min (197 m/min)
Range: 375 miles (604 km)
Number of seats: 2

1928 C-8W (C-8 MARK IV)

This model resembled its forerunners in being built round the fuselage of an Avro 504N, but it differed in having a more powerful American engine.

The C-8 Mark IV was the aircraft purchased by Harold Frank Pitcairn which, in December 1928, became the first autogiro to fly in the U.S.A. This machine is now preserved at the Smithsonian Institution in Washington, D.C.

In February 1929 the American rights in La Cierva's invention were acquired by Pitcairn's organization, which later became the Autogiro Company of America (see under U.S.A.).

Engine: Wright Whirlwind J-5, 225 h.p.
Rotor diameter: 39 ft 7 in (12·06 m)
Number of seats: 2

1927 C-9

This small single-seater autogiro had an engine of only 70 h.p. and was built for the British Air Ministry.

In 1930 it was placed in the Science Museum, South Kensington, London.

Engine: Armstrong Siddeley Genet 1, 70 h.p.
Rotor diameter: 30 ft (9·14 m)
Number of seats: 1

1928 C-12

The C-12 was fitted with floats and thus became the first hydrogyro to have flown.

Engine: Avro Alpha, 100 h.p.
Number of seats: 2

1928 C-17 MARK I, MARK II

The first version, which had an A.D.C. 85 h.p. Cirrus III engine, proved to be under-powered, so a second one with a greater power source and a four-bladed rotor was built.

Engine: Avro Alpha, 100 h.p.
Rotor diameter: 33 ft (10·06 m)
Cruising speed: (max.) 90 m.p.h. (145 k.p.h.)
Number of seats: 2

1929 C-19 MARK I, MARK II, MARK III

This model, first of the C-19 series, had a fuselage designed by La

Cierva, an Armstrong Siddeley Genet engine, and a feature also incorporated into the later Marks II and III: the rotor was started not by a crew of men pulling on a rope wound round it close to the hub, but by means of special elevators which deflected the airscrew's slipstream upwards to provide the necessary impetus. The new method had two advantages: it considerably reduced the time required for take-off and brought the taxiing distance down to a mere 30 yards (about 27 metres).

All three versions were two-seaters and had four-bladed rotors, the diameter of which, the same for Marks I and II, was increased for Mark III.

Engine: Armstrong Siddeley Genet II, 80 h.p.
Rotor diameter: (I and II) 30 ft (9·14 m)
(III) 35 ft (10·67 m)
Number of seats: 2

1931 C-19 MARK IV; 1932 C-19 MARK V

Both these two versions embodied a markedly improved method for starting the rotor by connecting it through a light clutch to the engine drive, which had recently been developed in the U.S.A.

The Mark IV made its maiden flight in 1931, the Mark V the following year. The later version was used by La Cierva to study the behaviour of a 'direct-control' head in substitution for the fixed head. By means of the new head, which was able to tilt in all directions, La Cierva obtained not only lateral but also fore-and-aft control.

Both versions in their final form had a three-bladed cantilever rotor of the same diameter (an experimental Mark V had a two-bladed rotor), and the Mark V had no stub wings.

The C-19 Mark IV was also built in Germany by Focke-Wulf (*q.v.*) under a licensing agreement.

Engine: Armstrong Siddeley Genet Major I, 100 h.p.
Rotor diameter: 34 ft (10·36 m)
Number of seats: 2

1934 C-30A

The prototype of this autogyro, built in the workshops of National Flying Services Ltd, Hanworth from C-19 components, had 'direct control', i.e. a rotor free to tilt in all directions by operating a hanging-stick control column.

After successful demonstrations the British Air Ministry invited the manufacturer to produce the aircraft in quantity under the designation of C-30A. The production version had a more powerful engine than the prototype, and in addition the three-bladed direct-control head was fitted with mechanical-drive starting gear.

Under licence A. V. Roe produced about 100 of these aircraft. Some 40

were built in Germany by Focke-Wulf, and about 100 in France by Lioré and Olivier, also under licence from La Cierva.

In 1935 the British licensee produced C-30s for the Royal Air Force and the Fleet Air Arm under the respective designations of Rota I and Rota II, both powered by a Civet I engine, the second provided with flotation gear.

Finally, a ski-fitted version was produced for Sweden.

In 1936 trials started on a C-30 embodying a so-called 'auto-dynamic' head, intended to ensure direct take-off without any forward run. The rotation of the blades set at a non-lifting angle was speeded up by the engine and as soon as sufficient kinetic energy had been stored the blade pitch was raised so that the autogyro could leave the ground vertically in a 'jump take-off'.

Though in the early trials this 'auto-dynamic' head set up unpredictable vibrations, it was incorporated into later models.

During World War II use was made of this autogyro's capacity to fly very slowly round a given point to calibrate radar equipment.

Engine: Armstrong Siddeley Genet Major IA, 140 h.p.
Rotor diameter: 37 ft (11·28 m)
Weight fully loaded: 1,900 lb (862 kg)
Cruising speed: (max.) 100 m.p.h. (161 k.p.h.)
Inclined climb: 900 ft/min (274 m/min)
Number of seats: 2

ROTAPLANE HAFNER

This autogyro glider, often referred to as the 'Rotachute', was developed during World War II by Raoul Hafner and the staff of the Airborne Forces Experimental Establishment at Beaulieu in Hampshire. It was designed to carry a paratrooper armed with a Bren gun after being dropped from a large transport aircraft designed for the purpose.

A change of policy in 1943 brought the development work to an end.

1942 ROTAPLANE

This autogyro glider consisted of a welded steel tube framework, carrying the rotor and having its rear part covered with rubberized fabric in which there were two small vertical shutters.

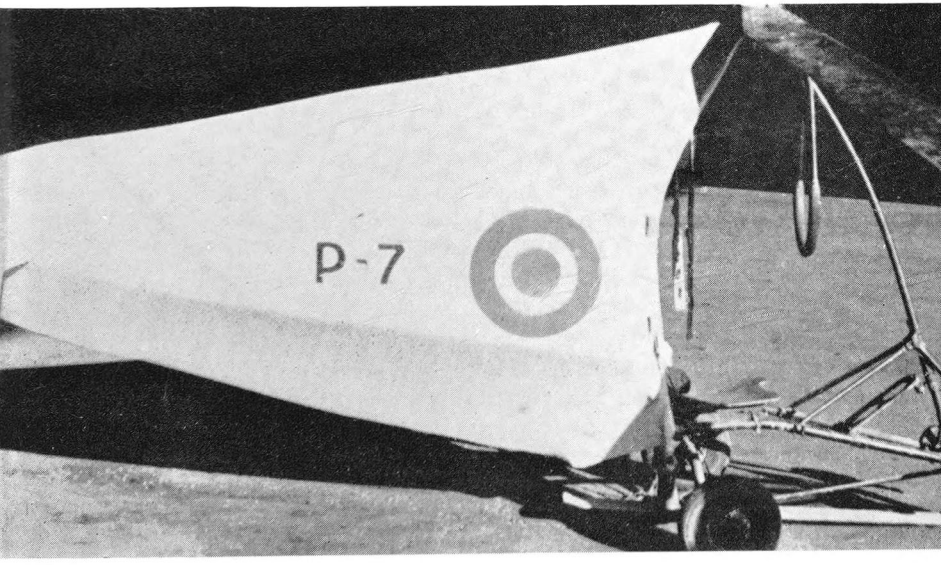
The rotor had two wooden blades articulating on the hub by means of steel hinges. The hub was attached to a small upright component by a rubber block acting as a universal joint, so that some vertical displacement could occur but vibrations were not transmitted to the main structure.

The rotor controls operated in the opposite way from those on an aircraft. To raise the nose, the control column was pushed forward; to bank to the right, the column was moved to the left.

The undercarriage originally consisted of two main wheels joined by an axle and placed almost directly below the rotor. Following towing tests behind a car, changes were made and in the Mark 2 a skid was added. Further tests resulted in the Mark 3, a version of greater length and with a rigid tail. This final prototype was extensively towed by a Tiger Moth and on several occasions released from a height of more than 3,500 feet (1,100 metres).

This rotorcraft may be compared with the German Focke-Achgelis Fa-330.

Engine: None
Height: 6 ft 10 in (2·08 m)
Rotor diameter: 15 ft (4·57 m)
Weight empty: 76 lb (34 kg)
Weight fully loaded: 295 lb (134 kg)
Cruising speed: (permissible max.) 93 m.p.h. (150 k.p.h.)
Number of seats: 1



ROTAPLANE

ROTORCRAFT

An original helicopter, designed by J. S. Shapiro, has been developed by Rotorcraft Ltd, a firm which later merged with the Cierva Autogiro Co. and became Cierva Rotorcraft Ltd.

1961 GRASSHOPPER I

This light two-seater helicopter is powered by two engines which drive two contra-rotating co-axial two-bladed rotors. There is a conventional control system and if the output of one engine falls off, the output of the other can be increased by adjustment of individual throttle settings. Yaw control is achieved by differential collective pitch. There is also a vee stabilizer at the end of the streamlined tail. Both engines and transmission are placed forward in a car-type bonnet with a view to easy maintenance. The maiden flight took place in March 1962.

Engines (2): Walter Mikron, 65 h.p. each
Length: 18 ft 4 in (5·59 m)
Width: 6 ft 2 in (1·88 m)
Height: 9 ft 4 in (2·85 m)
Rotor diameter (2): 25 ft (7·62 m)
Weight empty: 1,400 lb (635 kg)
Weight fully loaded: 2,000 lb (907 kg)
Cruising speed: 90 m.p.h. (145 k.p.h.)
Inclined climb: 1,000 ft/min (305 m/min)
Service ceiling: 12,000 ft (3,658 m)
Range: 210 miles (338 km)
Number of seats: 2

1964 GRASSHOPPER III

The Grasshopper II, developed from Grasshopper I, with two Walter Minor engines was not flown but a later version Grasshopper III has been developed with two Continental engines.

Engines (2): Rolls-Royce Continental O-300, 145 h.p. each
Length: 18 ft 4 in (5·59 m)
Width: 5 ft 2 in (1·58 m)
Height: 9 ft 3 in (2·82 m)
Rotor diameter (2): 32 ft (9·75 m)
Weight empty: 1,630 lb (739 kg)
Weight fully loaded: 3,050 lb (1,383 kg)
Cruising speed: 110 m.p.h. (177 k.p.h.)
Inclined climb: 1,230 ft/min (375 m/min)
Service ceiling: 12,000 ft (3,658 m)
Range: 250 miles (402 km)
Number of seats: 4

SAUNDERS-ROE

Since 1912, when it produced an amphibious aircraft, it has been a tradition with this Isle of Wight firm to concentrate on the production of

seaplanes, mainly of the long-range type such as the Princess. This firm was also the first in the United Kingdom to set about building a jet flying-boat fighter.

On 22 January 1951, Saunders-Roe took over the Cierva Company and the greater part of the technical staff who had worked on the Air Horse and were then engaged on the Skeeter 3 light helicopter. The new Saunders-Roe helicopter department also conducted research into the application of pulse-jets to the tips of helicopter blades, and the first designs tested gave a thrust of 45 pounds (20·5 kilos).

In 1959, Westland took over Saunders-Roe's aviation interests and continued to develop the P-531, from which it finally produced the Wasp and the Scout.

1951 SKEETER 3B, 4 AND 5

On continuing the Cierva Autogiro Company's work on the Skeeter, Saunders-Roe gave it a more powerful engine. Mark 4 is the version made for the Royal Navy, Marks 3B and 5 being civil versions.

The Mark 5 made its maiden flight in 1953.

Engine: Blackburn Bombardier, 180 h.p.
Length: 31 ft 2 in (9·5 m)
Height: 9 ft 10 in (3 m)
Rotor diameter: 32 ft (9·75 m)
Weight fully loaded: 2,100 lb (953 kg)
Cruising speed: 88 m.p.h. (142 k.p.h.)
Inclined climb: 880 ft/min (268 m/min)
Absolute ceiling: 11,300 ft (3,444 m)
Range: 265 miles (426 km)
Number of seats: 2

1954 SKEETER 6

This side-by-side two-seater, built in light alloy, had its fuel tank located in the forepart of the fuselage. An additional tank or payload could, if necessary, replace the removable passenger seat.

The three-bladed rotor consisted of a length of steel rod with a wood and fabric covering; the two-bladed anti-torque airscrew was of impregnated wood.

As compared with the Cierva Autogiro Company's Skeeter 1, the Skeeter 6 had virtually twice the power and also a 50 per cent increase in all-up weight.

This helicopter's rotor was used for tests of the Napier NRE-19 hydrogen peroxide rockets. The fuel tank placed above the rotor head fed the pressure chambers at the tip of the blade, and the net thrust obtained was 60 (hgp). As a result, the rate of inclined climb was appreci-

ably increased. The 90 pounds (41 kilos) of hydrogen fuel provided maintain combustion for only two minutes.

Engine: De Havilland Gipsy Major, 200 h.p.
Length: 28 ft 5 in (8·66 m)
Width: 7 ft 4½ in (2·24 m)
Height: 10 ft 2 in (3·1 m)
Rotor diameter: 32 ft (9·75 m)
Weight fully loaded: 2,200 lb (998 kg)
Cruising speed: 101 m.p.h. (163 k.p.h.)
Absolute ceiling: 11,900 ft (3,627 m)
Range: 260 miles (418 km)
Number of seats: 2

SKEETER 6

1956 SKEETER 12

This two-seater helicopter can be fitted with a skid landing gear as an alternative to the tricycle. The military designation is AOP Mark 12; twelve of these have been ordered by the British Army for AOP and light-duty liaison work.

A purchase has also been made by the Federal German Army and Navy. The trainer version is designated T Mark 13.

1958 P-531

This five-seater's dimensions are larger than those of the Skeeter: the rotor has four instead of three blades.

This turbine-powered helicopter was built as a private venture in only seven months. It made its maiden flight on 20 July 1958. It was designed to absorb power up to 650 s.h.p. which would enable it to be fitted with suitably derated engines in the 800 to 1,000 s.h.p. range. Some of these

rotorcraft, fitted with a 425 s.h.p. Blackburn Turmo-600 Series 3 turbine engine, underwent evaluation tests with the Fleet Air Arm.

From 1959 onwards development continued under the aegis of Westland and under the new names of Scout and Wasp. In 1959 a P-531-2 version made its appearance, powered this time with a Blackburn A-129 of 970 s.h.p. derated to 635 s.h.p. A similar helicopter was equipped with a De Havilland Gnome, also derated. The Mark 2 had a redesigned transmission system, new rotor blades and a modified tail boom with skid landing gear instead of the four wheels of the first prototype.

SHORT

Founded in 1898 for the purpose of manufacturing spherical balloons, Short Brothers is the oldest aeronautical firm in the United Kingdom. Latterly the company specialized in the construction of military aircraft and flying-boats such as the Sunderland.

After a change of name to Short Brothers and Harland, construction of these aircraft was continued and research work started on guided missiles and an aero-isoclinic wing aircraft.

In 1927 Short Brothers built an autogyro, under licence from La Cierva.

1927 SHORT 31/26

This rotorcraft had a single four-bladed rotor of a size somewhat large for its period. The fuselage was designed by Gouge, and his design also included the wings, ailerons and rudder.

Engine: Jupiter, 485 h.p.

Rotor diameter: 52 ft 6 in (16 m)

THRUXTON

The Thruxton Aviation and Engineering Company, a subsidiary of the Wiltshire School of Flying, designed a small autogyro of conventional appearance with a pusher propeller.

1964 ES-101 GADFLY

This autogyro has a two-bladed see-saw-system rotor attached rigidly to the hub. A clutch is located between the engine and the driveshaft to engage the rotor drive. The engine is mounted directly behind the mast and drives a fixed-pitch pusher propeller. In the slipstream there is a fixed-plane stabilizing surface and a rudder.

The cabin is fully enclosed in perspex; the landing gear consists of

three wheels. The minimum speed is 25 m.p.h. (40 k.p.h.) and the take-off distance is about 100 feet (30·5 m).

Engine: Rolls-Royce Continental IO-346, 165 h.p.
Length: 11 ft (3·35 m)
Width: 6 ft (1·83 m)
Rotor diameter: 30 ft (9·14 m)
Cruising speed: 110 m.p.h. (177 k.p.h.)
max: 115 m.p.h. (185 k.p.h.)
Inclined climb: 1,500 ft/min (457 m/min)
Service ceiling: 14,000 ft (4,267 m)
Number of seats: 2

WALLIS

About 1958 K. H. Wallis built a Bensen Gyro-Copter and, through the experience gained, built a second machine embodying a number of modifications of his own which considerably improved performance. Wallis contacted British Executive and General Aviation Ltd with a view to the production of a few autogyros intended to be evaluated by the Army Air Corps for spotting and liaison work. When no tangible result materialized from the British Army, K. H. Wallis set up his own company, Wallis Autogyros Ltd, based at Cambridge.

1962 WA-116

In its final form the WA-116 was built with the help of Beagle. It has the appearance of an ultra-light single-seater autogyro with a conventional stick. Its two-bladed rotor has an offset-gimbal rotor head. It can, if necessary, be fitted with a lighter cockpit.

It can take off in 30 yards (27·5 metres) and its minimum speed is of the order of 14 m.p.h. (22 k.p.h.).

Engine: McCulloch 4318, 72 h.p.
Width: 5 ft 4 in (1·63 m)
Height: 6 ft 1 in (1·85 m)
Rotor diameter: 20 ft 2 in (6·15 m)
Weight empty: 295 lb (134 kg)
Weight fully loaded: 550 lb (249 kg)
Cruising speed: 60 m.p.h. (97 k.p.h.)
Inclined climb: 1,000 ft/min (305 m/min)
Service ceiling: 11,000 ft (3,352 m)
Range: 100 miles (161 km)
Number of seats: 1

1965 WA-117

This is a WA-116 equipped with a more powerful engine, a Rolls-Royce Continental O-200-A of 100 h.p.

1965 WA-118 METEORITE

The WA-118, fitted with a Meteor Alfa I supercharged engine, is used as a test vehicle for high-speed flight characteristics. The first flights were made in 1966.

WEIR

The important Scottish firm of G. & J. Weir, with registered offices at Glasgow, first became interested in rotary wings in 1932. Its first autogyro, built under licence from La Cierva, made its maiden flight in June 1933.

It is interesting to recall that at about the same period (i.e. 1934) Otto Reder, working with Weir, fitted an auto-rotating rotor system to a 'gyro-boat', a small craft of the Redwing class, which was tested on the Solent. Instead of a sail there was a rotor set vertically and with a diameter of 18 feet (5·49 metres).

In 1937, after having built several autogyros, the firm followed suggestions made by C. G. Pullin and began to investigate pure helicopters. The first idea tried was co-axial contra-rotating rotors, but this was abandoned in favour of the two lateral rotors as found, for instance, in the German Focke 61 helicopter. Thus, in 1938, Weir produced the first British helicopter actually to fly. All work in this field was stopped in 1943.

In 1943 the Cierva Company took over G. & J. Weir's rotary-wing activities, and with C. G. Pullin as managing director started developmental work for the construction of a research helicopter.

1933 C-28 (W-1)

This single-seater autogyro with a fuselage designed by Pullin had a two-bladed rotor, the blades of which were fitted with flapping and drag hinges, while the head was of the 'direct-control' type. A mechanical-drive starting device was used to set the rotor in motion.

The first flights took place at Hanworth in May 1933.

Engine: Douglas Dryad, 40 h.p.
Rotor diameter: 28 ft (8·53 m)
Number of seats: 1

1934 W-2

This autogyro bore a close resemblance to its predecessor, apart from certain structural modifications and a more powerful engine. It made its maiden flight in 1934.

The second prototype served mainly for testing the 'auto-dynamic' head required by a 'jump take-off' and which was used in the following autogyro, the W-3.

Engine: Weir, 50 h.p. flat twin
Rotor diameter: 28 ft (8·53 m)
Number of seats: 1

1936 W-3

This single-seater was powered by an inverted 4-cylinder in-line engine and fitted with a two-bladed 'auto-dynamic' rotor. It could make a 'jump take-off': to do this, the rotor was run at overspeed in flat pitch, then suddenly given sufficient positive pitch to produce the jump while the engine was declutched.

The W-3 was publicly displayed at Hounslow Heath on 23 July 1936.

Engine: Weir, 50 h.p.
Length: 14 ft 4 in (4·37 m)
Height: 7 ft 1 in (2·16 m)
Rotor diameter: 18 ft 7 in (5·66 m)
Weight fully loaded: 650 lb (295 kg)
Number of seats: 1

1936 W-4

This was an improved version of the W-3, in which the single seat, engine, and two-bladed 'auto-dynamic' rotor for direct take-off were retained.

Engine: Weir, 50 h.p.
Number of seats: 1

1937 W-5

Weir's chief designer, C. G. Pullin, first considered converting the W-4 autogyro into a helicopter by using two co-axial rotors, but he finally adopted the system of rotors carried by outriggers on either side of the fuselage, like the record-breaking Focke 61.

The W-5 was a single-seater powered by an air-cooled engine; each of the two-bladed rotors had cyclic and collective pitch control and they turned at 430 r.p.m.

This helicopter made its first flight at Dalrymple, Ayrshire, on 7 June 1938, when it was piloted by R. A. Pullin, son of the chief designer. By the outbreak of World War II it had logged eighty hours' flying time.

Engine: Weir, 50 h.p.
Rotor diameter: 15 ft (4·57 m)
Weight fully loaded: 840 lb (381 kg)
Cruising speed: (max.) 70 m.p.h. (113 k.p.h.)
Inclined climb: 400 ft/min (122 m/min)
Number of seats: 1

1938 W-6

Much larger than its predecessors, this two-seater helicopter was powered by a more powerful fan-cooled engine located in the nose. Each of the two rotors had three blades made of compressed wood with leading edges in metal. They rotated at 275 r.p.m. and had both cyclic and collective control all enclosed within the hub. A ratchet-type freewheeling device was used for flying in auto-rotation.

The maiden flight took place in Scotland in October 1939, but World War II, then in its early stages, caused all work to be stopped on the W-6 in the middle of 1940.

Engine: De Havilland Gipsy, 205 h.p.
Length: 28 ft (8·53 m)
Height: 10 ft 6 in (3·2 m)
Rotor diameter: 25 ft (7·62 m)
Weight fully loaded: 2,360 lb (1,070 kg)
Cruising speed: 80 m.p.h. (129 k.p.h.)
Inclined climb: 650 ft/min (198 m/min)
Absolute ceiling: 12,500 ft (3,810 m)
Number of seats: 2

WESTLAND AIRCRAFT LTD

Several changes have taken place in this company, which started off as a branch of the well-known petrol-engine makers, Petters Ltd, Westland Aircraft Works. In 1935 Westland Aircraft Ltd was formed to take over that subsidiary; the new company later produced various aircraft which made a name for themselves. Among them are the Lysander army co-operation aircraft, the series of Whirlwind fighters, the high-altitude interceptor Welkin, and the turboprop Wyvern, a naval fighter-aircraft going back to 1949.

Today, helicopters are the main product of the company's factories at Yeovil. The trend, first seen in 1934 and 1935, took shape in 1947 when Westland obtained the right to manufacture the Sikorsky S-51 under licence and then the Sikorsky S-55 in 1951. Both aircraft were modified to meet the requirements of British Airworthiness Regulations. Later, licences were granted Westland to build further Sikorsky models. By 1949 Westland was the leading European helicopter manufacturer. Its factories on their own produced more of these aircraft than the rest of the United Kingdom and Continental factories together.

As part of the concentration which took place in the British aerospace industry in 1959 and 1960, Westland in the former year took over the Saunders-Roe Helicopter Division and in the latter the rotary-wing interests of the Fairey and Bristol companies.

In 1959 Westland built the United Kingdom's first city-centre heliport.

Furthermore, about 1961 Westland entered into a licensing agreement with Boeing's Vertol Division for the production of its Model 107.

In the two decades since Westland's first licensing agreement with Sikorsky, it has built approximately 900 helicopters.

Westland's pre-war production consisted of two autogyros with cabins: the Cierva-Lepère CL-20 and the C-29. The post-war Sikorsky licences have resulted in a long series of rotorcraft, details of which are given below.

S-51		*S-55*
Dragonfly HR-1	Series 1	Whirlwind HAR-1
Dragonfly HC-2		Whirlwind HAR-2
Dragonfly HR-3		Whirlwind HAR-3
Dragonfly HC-4		Whirlwind HAR-4
Widgeon	Series 2	Whirlwind HAR-5
		Whirlwind HAS-7
		Whirlwind HCC-8
	Series 3	Whirlwind HAR-10
		Whirlwind HCC-12

S-56	*S-58*
Westminster	Wessex HAS-1
	Wessex HC-2
	Wessex HAS-3
	Wessex HAS-31
	Wessex HU-5
	Wessex 52
S-61	Wessex 53
SH-3D Sea King	Wessex 60 Series

1934 C-29

This experimental five-seater autogyro, constructed in Duralumin tubing, was designed in collaboration with Juan de la Cierva. It was fitted with a 14-cylinder double-bank air-cooled radial engine, and its rotor head was of the direct-control type.

This aircraft never flew. Ground tests revealed a large amount of ground resonance, but before this could be rectified La Cierva died and the work was abandoned.

Engine: Armstrong Siddeley Panther, 600 h.p.
Length: 38 ft (11·58 m)
Height: 12 ft 9 in (3·89 m)
Rotor diameter: 50 ft (15·24 m)
Weight empty: 3,221 lb (1,461 kg)

C-29

Weight fully loaded: 5,000 lb (2,268 kg)
Inclined climb: 1,500 ft/min (457 m/min)
Number of seats: 5

1934 CL-20

The letters in this designation stand for La Cierva and Lepère. Lepère was at that time working with Lioré and Olivier, holders of the Cierva licences for France, and it was he who designed this aircraft.

It had a 7-cylinder radial engine, and the rotor with a 'direct-control' head consisted of three untapered blades on flapping and drag hinges. To facilitate parking in a restricted space, the blades could be folded back.

The earliest flights of this aircraft were in 1935.

Engine: Pobjoy Niagara S, 90 h.p.
Length: 20 ft 3 in (6·17 m)
Height: 10 ft 3 in (3·12 m)
Rotor diameter: 32 ft (9·75 m)
Weight empty: 840 lb (381 kg)
Weight fully loaded: 1,400 lb (635 kg)
Number of seats: 2

1947 WESTLAND S-51 (DRAGONFLY)

Following negotiations with the Sikorsky Division of United Aircraft Corporation to manufacture the S-51 in the United Kingdom, a licensing agreement was signed on 10 January 1947. Westland began assembling U.S. components with a 450 h.p. Pratt and Whitney R-985 Wasp engine. The designation of this rotorcraft was WS-51 Mark 1B. In 1948, an S-51,

CL-20

re-engined with an Alvis Leonides 521/1, was given the designation WS-51 Mark 1A.

Orders from the services gave rise to several variations of the Dragonfly. In these helicopters, the power plant, a 9-cylinder radial engine, was mounted horizontally on a welded steel tube ring above the bottom truss of the centre section of the helicopter. It drove the rotor head through a vertical shaft and a two-stage epicyclic reduction. The main rotor head had hinged connections to the three all-metal blades, which were free to flap up and down, but hydraulically damped about the drag hinges. Pitch control depended upon a rotating swash plate linked to a fixed swash plate which could be tilted in all directions and raised or lowered by the action of hydraulically operated servo-jacks to ensure cyclic and collective control.

Engine: Alvis Leonides, 500 h.p.
Length: 41 ft $1\frac{3}{4}$ in (12·52 m)
Height: 12 ft $11\frac{3}{8}$ in (3·94 m)
Rotor diameter: 48 ft (14·63 m)
Weight empty: 4,124 lb (1,871 kg)
Weight fully loaded: 5,374 lb (2,438 kg)
Cruising speed: 85 m.p.h. (137 k.p.h.)
max: 105 m.p.h. (169 k.p.h.)
Inclined climb: 680 ft/min (207 m/min)

WESTLAND S-51

Absolute ceiling: 14,000 ft (4,267 m)
Range: 300 miles (483 km)
Number of seats: 4

The following are the various military types of the Dragonfly S-51, of which 139 have been built in all.

1949 DRAGONFLY HR MARK 1

This member of the S-51 family was produced specially for the Royal Navy, and equipment was modified to make the aircraft specially suited for air-sea rescue work. This version was powered by a 540 h.p. Alvis Leonides 50.

1950 DRAGONFLY HC MARK 2

Yet another version of the S-51, this model, especially built for the R.A.F. and fitted with an Alvis Leonides engine, was designed to carry one stretcher on each side of the outer surface of the fuselage.

1951 DRAGONFLY HR MARK 3

This member of the family, also used by the Fleet Air Arm, closely resembles the Mark 1, but the rotor blades are of all-metal construction and are fitted with a hydraulic servo-control system.

1952 DRAGONFLY HC MARK 4

This member of the family, also made to R.A.F. specifications, similarly

had an Alvis Leonides engine and a rotor with all-metal blades as well as a hydraulic servo-control system.

1955 WIDGEON

This development by the Westland team of designers from the Dragonfly series made its maiden flight at Yeovil on 23 August 1956. The restyling carried out gave the Widgeon an S-55 Whirlwind rotor head. The latter makes use of an offset flapping-hinge system, which allows for more latitude in respect of the helicopter's centre of gravity, while the Dragonfly's flapping hinge was set in the centre line of the hub. The new system can cope with shifts in centre of gravity, and obviates the need for carrying ballast weights to compensate for variation in load. An additional feature is that the Widgeon's head is operated by servo-controls.

The cabin has been completely redesigned. In the present form it carries a pilot and also four passengers, or instead of passengers two stretchers which can be loaded through a nose door. A winch has been fitted on the right-hand side for emergency use; the winch is under direct control by the pilot, who can carry out any operation in which it is used without help from another person. In all some fifteen Widgeons were built.

Engine: Alvis Leonides 521/1, 520 h.p.
Length: 41 ft $2\frac{3}{4}$ in (12·56 m)
Height: 12 ft $11\frac{3}{8}$ in (3·95 m)
Rotor diameter: 49 ft 2 in (14·99 m)
Weight empty: 4,424 lb (2,007 kg)
Weight fully loaded: 5,900 lb (2,676 kg)
Cruising speed: 80 m.p.h. (129 k.p.h.)
max: 95 m.p.h. (153 k.p.h.)
Inclined climb: 970 ft/min (297 m/min)
Range: 300 miles (483 km)
Number of seats: 5

WIDGEON

1951 WESTLAND S-55 (WHIRLWIND)

This Westland version of the Sikorsky S-55 is also one member of a fairly large family. Conceived primarily as a general-purpose or utility helicopter, it is built extensively from alloys of the ultra-light metal magnesium and is of semi-monocoque construction. Westland obtained a licence on the Sikorsky S-55 on 15 November 1950.

This rotorcraft, with a rotor hydraulically operated for both cyclic and collective pitch controls, had its engine placed in the nose behind two clamshell doors. This siting of the engine has made it possible to place the cabin directly under the centre line of the main rotor. The pilot's compartment is situated both above and forward of the cabin, the capacity of which is three times that of the S-51. It can thus serve any one of three purposes: carrying ten passengers, transporting six stretchers, or moving a load of freight. This machine can also be equipped with an Alvis engine or a turbine produced by De Havilland (later Bristol Siddeley Engines and now the Small Engine Division of Rolls-Royce).

Engine: Pratt and Whitney R-1340, 600 h.p.
Length: 42 ft (12·8 m)
Height: 13 ft 2½ in (4·02 m)
Rotor diameter: 53 ft (16·15 m)
Weight empty: 5,010 lb (2,273 kg)
Weight fully loaded: 7,500 lb (3,402 kg)
Cruising speed: 86 m.p.h. (138 k.p.h.)
max: 109 m.p.h. (175 k.p.h.)
Inclined climb: 750 ft/min (229 m/min)
Service ceiling: 15,700 ft (4,785 m)
Range: 333 miles (536 km)
Number of seats: 12
or:
Engine: Bristol Siddeley Gnome H.1000, 1,050 s.h.p.
Weight empty: 4,760 lb (2,159 kg)
Weight fully loaded: 8,000 lb (3,629 kg)
Cruising speed: 104 m.p.h. (167 k.p.h.)
Inclined climb: 1,220 ft/min (372 m/min)
Service ceiling: 16,600 ft (5,060 m)
Range: 300 miles (483 km)

The various versions of the Westland S-55 are:

1952 WHIRLWIND SERIES 1

There is one civil version equipped with an American 600 h.p. Pratt and Whitney R-1340 or a 700 h.p. Wright R-1300 engine, and various service versions: Whirlwind HAR Marks 1–4.

WHIRLWIND

1952 WHIRLWIND SERIES 2

The civil version is equipped with a 750 h.p. Alvis Leonides Major 755. The service versions are Whirlwind HAR-5; HAS-7; HCC-8.

1959 WHIRLWIND SERIES 3

The civil version is equipped with a 1,050 s.h.p. Bristol Siddeley Gnome free-turbine engine mounted in the nose. The first Series 3 Whirwind to fly, at the end of February 1959, was equipped with a General Electric T58, from which the Gnome is derived. The British Gnome was first tested in flight on a Whirlwind in September 1959. The service versions are: HAR-10 and HCC-12.

1951 WHIRLWIND HAR MARK 1

This member of the family, powered by a Pratt and Whitney engine with a 10:1 blower ratio, was specially designed for use in the Royal Navy.

1951 WHIRLWIND HAR MARK 2

This helicopter is identical with the HAR-1, but was built specially to meet the requirements of the R.A.F. Coastal Command. The HAR-2 can be used for paratroop transport and supply dropping.

1955 WHIRLWIND HAR MARK 3

This member of the family is fitted with a more powerful 700 h.p. Wright 1300-3 engine and was specially designed for the Royal Navy.

1954 WHIRLWIND HAR MARK 4

This version is identical with the HAR-1, except that its engine (a Pratt and Whitney R-1340-57) has a 12:1 and not a 10:1 blower ratio. It was intended for use by the R.A.F.

1955 WHIRLWIND HAR MARK 5

This version bears a very strong family resemblance to the Series 1 Whirlwinds, but instead of an American power plant it has a 750 h.p. Alvis Leonides Major 755 engine. This change, necessitating only slight modifications to the engine-bay doors, produced considerably improved performance. This helicopter, which made its maiden flight in August 1955, is a Royal Navy search and rescue version equivalent to the civil helicopter in Whirlwind Series 2.

1956 WHIRLWIND HAS MARK 7

This anti-submarine version, resembling the former variant, is equipped with a 750 h.p. Alvis Leonides Major engine.

Whirlwinds HAR Mark 5 and HAS Mark 7 are being progressively replaced by the Wessex.

1959 WHIRLWIND HCC MARK 8

This Series 2 variant, equipped with a 740 h.p. Alvis Leonides Major engine, has been in service with the Queen's Flight.

1961 WHIRLWIND HAR MARK 10

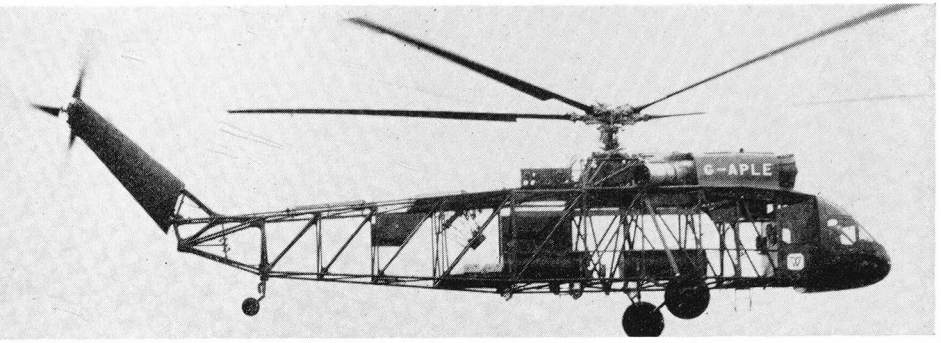
This military version of the Whirlwind Series 3 was developed from the piston-engine Whirlwind of which more than four hundred were produced. The HAR Mark 10 is powered by a 1,050 s.h.p. Bristol Siddeley Gnome free-turbine engine and is in full operational service with the R.A.F. The only external difference from the preceding helicopters is a longer nose and a jet-pipe outlet on the port side of the fuselage. It should be noted that the earlier piston-engined Whirlwinds can be converted to the Gnome turbine.

1964 WHIRLWIND HCC MARK 12

This is an HAR-10-type helicopter, which has replaced the preceding Whirlwind HCC Mark 8 in the Queen's Flight.

1955 WESTLAND S-56 (WESTMINSTER)

The Westminster, developed as a private venture, was the largest classical helicopter built in the United Kingdom at the time. Derived from the Sikorsky S-56, for which a licensing agreement was signed towards the middle of 1955, it had two shaft-turbine engines mounted on the cabin top instead of two Pratt and Whitney piston engines. It also had



WESTMINSTER

a new fuselage. It preserved the Sikorsky five-bladed rotor and control system. The blades were all-metal and were mounted with flapping hinges and hydraulic drag-dampers. Pitch changes were brought about through a fixed- and rotating-star swash-plate system.

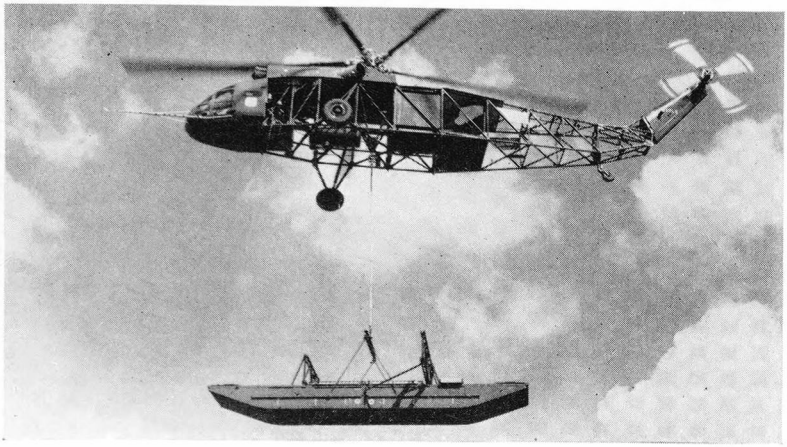
The prototype of the Westminster crane-transporter version, which made its maiden flight on 15 June 1958, had an open tubular framework fuselage structure with a monocoque cockpit.

A second prototype was also built, powered by a pair of Napier Eland 229 rear-drive turboshaft engines. With its streamlined fuselage, it could carry fifty-one fully-equipped troops.

Engines (2)*:* Napier Eland E-229, 2,900 s.h.p. each
Length: 71 ft 4 in (21·74 m)
Width: 19 ft 9 in (6·02 m)
Height: 18 ft 4 in (5·59 m)
Rotor diameter: 72 ft (21·95 m)
Weight empty: 21,245 lb (9,637 kg)
Weight fully loaded: 36,000 lb (16,330 kg)
Inclined climb: 1,200 ft/min (366 m/min)
Range: 180 miles (290 km)
Number of seats: 40

1957 WESTLAND S-58 (WESSEX)

The Royal Navy required a helicopter able to perform the duties of two Whirlwinds, *viz.* hunting and striking and general naval helicopter missions. To meet these needs Westland decided to replace the original Wright R-1820 piston engine on the American S-58 by a Napier Gazelle free-turbine engine pitched at an angle of 35 degrees to the horizontal, and an agreement to build the S-58 under licence was signed in 1956. First test



WESTMINSTER (CRANE)

flights with an imported S-58 modified to take a turbine took place on 17 May 1957. In June 1958 a Westland-built S-58 carried out its flight trials. Fitting a turbine necessitated a slight increase in fuselage length to accommodate the greater length of the Gazelle turbine. An automatic pilot with gyroscopic compass is fitted in the Wessex. It should be noted that there is also a Wessex with two Gnome-type turbine engines.

Both the main and the tail rotors have four all-metal blades; thanks to a folding-tail unit the Wessex can be easily accommodated on an aircraft carrier lift. The Wessex has an undercarriage with three and not four wheels as in the Whirlwind.

Although originally designed for use with the Royal Navy, the Wessex is further produced in a transport version which can carry sixteen fully-equipped troops, eight stretchers, or, as a civil aircraft, twelve passengers.

1960 WESSEX HAS MARK 1

With the exception of the welded steel tubular structure in the region of the main gearbox and the rotor head pylon, the Wessex is built in light-alloy monocoque. The main rotor has four blades of light alloy and the rotor head incorporates both flapping and drag hinges. These are offset from the rotor centre-line, thus providing a wide range of centre of gravity travel. This aircraft is auto-stabilized.

The power plant is a Napier Gazelle free-turbine engine with one-hour rating at 1,450 s.h.p. and continuous 1,200 s.h.p. rating.

Since this helicopter is primarily designed for anti-submarine warfare it can be provided with search equipment such as an Asdic unit and other

associated items; it can also carry a variety of strike weapons. The structure of the Wessex has also been designed to withstand the loads imposed by using mine-sweeping equipment. Furthermore, every HAS Mark 1 is delivered to the Royal Navy with fifteen troop seats.

Engine: Rolls-Royce (Napier) NGa-13R, 1,450 s.h.p.
Length: (fuselage) 48 ft 4 in (14·73 m)
Width: 13 ft 4 in (4·06 m)
Height: 16 ft 2 in (4·93 m)
Rotor diameter: 56 ft (17·07 m)
Weight empty: 7,600 lb (3,447 kg)
Weight fully loaded: 12,600 lb (5,715 kg)
Cruising speed: 126 m.p.h. (203 k.p.h.)
max: 132 m.p.h. (212 k.p.h.)
Inclined climb: 1,750 ft/min (533 m/min)
Service ceiling: 12,500 ft (3,810 m)
Range: 391 miles (629 km)
Number of seats: 14–18

WESSEX HAS-1

1962 WESSEX HC MARK 2

This general-purpose helicopter—the twin 'Gnome Wessex'—which made its maiden flight in January 1962, is powered by two Bristol Siddeley Gnome free-turbine engines, i.e. the British version, built under licence, of the American General Electric T58.

Developed from the Wessex HAS-1, it is markedly more powerful, since the two turbines give a total output of 2,700 s.h.p., whereas the HAS-1 transmission is limited to 1,450 s.h.p. The increased power is

thus 1,250 s.h.p. A feature of each installation is the automatic control which varies the power output to maintain a selected revolution rate irrespective of collective pitch setting.

This helicopter is in service with the R.A.F. Transport Command.

Engines (2)*:* Bristol Siddeley Gnome H.1200, 1,350 s.h.p. each
Length: (fuselage) 49 ft 11 in (15·21 m)
Width: 12 ft 6 in (3·81 m)
Height: 16 ft 2 in (4·93 m)
Rotor diameter: 56 ft (17·07 m)
Weight empty: 7,850 lb (3,560 kg)
Weight fully loaded: 13,500 lb (6,123 kg)
Cruising speed: 126 m.p.h. (203 k.p.h.)
max: 132 m.p.h. (212 k.p.h.)
Inclined climb: 1,700 ft/min (518 m/min)
Service ceiling: 10,000 ft (3,048 m)
Range: 310 miles (499 km)
Number of seats: 14–18

1965 WESSEX HAS MARK 3

This Wessex 3, which entered into service with the Royal Navy in 1967, is nicknamed 'The Camel' because of its hump radome just aft of the rotor head. It is an improvement upon the Wessex HAS Mark 1 because of its up-to-date sonar equipment and radar. Automatic flight-control systems enable the Mark 3 to perform in widely differing climatic conditions its duties of anti-submarine search and strike operations from either aircraft-carrier or shore bases.

Powered by a single Napier Gazelle NGa-22 gas-turbine rated at 1,600 s.h.p., the Mark 3 with a crew of four has a load available for sonar, weapons and fuel of 3,312 pounds (1502 kilos).

1962 WESSEX HAS MARK 31

This anti-submarine version was ordered by the Royal Australian Navy in June 1961. In appearance it resembles the basic Wessex HAS Mark 1 but incorporates special equipment to meet Australian requirements.

This helicopter's power lies midway between the Wessex HAS Mark I and HAS Mark 3. The engine is a 1,540 s.h.p. Napier Gazelle 162 turbine.

1963 WESSEX HU MARK 5

This helicopter, in many respects similar to the R.A.F. Wessex HC Mark 2, has been developed for the Royal Navy as a Commando carrier to replace the Series 2 Whirlwinds.

Power is supplied by two 1,350 s.h.p. Bristol Siddeley Gnome 112/113 turbines.

WESSEX HU MK 5

1964 WESSEX MARK 52

This is the designation of the Wessex equipped with two 1,350 s.h.p. Bristol Siddeley Gnome turbines supplied to the Iraq Air Force, while the Wessex Mark 53 is the variant supplied to the Ghana Air Force.

1965 WESSEX 60

This civil version of the Wessex is powered by two 1,350 s.h.p. Bristol Siddeley Gnome turbines. In respect it is similar to the Wessex HC Mark 2.

From 1966–7 onwards a number of these machines were operating in support of oil and natural gas exploration being carried out by several major oil companies in the North Sea.

1951 W-80 (PROJECT)

This helicopter was planned to have a single four-bladed rotor head driven by two engines mounted outboard in nacelles. The two engines were to have their driving shafts at right-angles to the line of flight and inclined towards the main gearbox situated above the roof of the passenger accommodation, the capacity of which was to be 1,525 cubic feet (about 43 cubic metres).

This helicopter was designed for passenger traffic in inter-city and feeder airline work.

Engines (2)*:* Bristol Hercules

WESSEX 60

Length: (fuselage) 69 ft (21·03 m)
Width: (fuselage) 9 ft 6 in (2·9 m)
Height: 16 ft (4·88 m)
Rotor diameter: 94 ft (28·65 m)
Weight fully loaded: 24,500 lb (11,113 kg)
Cruising speed: 187 m.p.h. (301 k.p.h.)
Number of seats: 30

1951 W-85 (PROJECT)

This large-size helicopter was to be powered by a pair of small turbo-jets mounted on each tip of a three-bladed rotor.

The main cabin, with a volume of 4,400 cubic feet (over 120 cubic metres), was to carry either 102 passengers, or a military payload of three guns and three jeeps, together with twelve to fifteen troops and their equipment.

Engines (6)*:* Armstrong Siddeley Adder gas-turbine or equivalent
Length: (fuselage) 64 ft (19·51 m)
Width: (fuselage) 12 ft 6 in (3·81 m)
Height: 18 ft (5·49 m)
Rotor diameter: 104 ft (31·7 m)
Weight empty: 20,700 lb (9,389 kg)
Weight fully loaded: 60,000 lb (27,215 kg)
Cruising speed: 105 m.p.h. (169 k.p.h.)
Number of seats: 102

1951 W-90 (PROJECT)

The W-90 is unquestionably the largest helicopter so far known to have been in design. It was to be powered by a gas-turbine mounted at the tip

of each of the three rotor blades. Its main cabin, the cubic capacity of which was to be 30,500 cubic feet (about 864 cubic metres), was planned to carry 450 troops.

Engines (3)*:* Armstrong Siddeley Sapphire, equivalent to 24,000 s.h.p.
Length: (fuselage) 124 ft (37·8 m)
Width: (fuselage) 21 ft (6·4 m)
Height: 37 ft (11·28 m)
Rotor diameter: 196 ft (59·74 m)
Weight empty: 90,000 lb (40,823 kg)
Weight fully loaded: 206,000 lb (93,440 kg)
Range: 230 miles (370 km)
Number of seats: 450

1966 WESTLAND S-61 (SH-3D SEA KING)

In 1966 Westland obtained the largest helicopter order ever placed in Britain. It was to supply the Royal Navy with SH-3Ds built under licence. This helicopter is a Royal Navy anti-submarine version of the S-61. It is in fact a British Sea King equipped with two Bristol Siddeley Gnome H.1400 turbines each rated at 1,500 s.h.p. and with British radar and electronic systems.

Westland secured the licence to build the S-61; in 1960 there was a scheme to build it under the name of 'Wiltshire'.

SH-3D SEA KING

BELVEDERE 192

The Belvedere is the Bristol 192 (*q.v.*) acquired by Westland when it took over the Bristol helicopter interests. The last Belvedere was delivered in 1962.

ROTODYNE

See Fairey Rotodyne (1953).

1959 SCOUT

The Scout is a development of the Saunders-Roe P-531 prototype, of which the maiden flight was made in July 1958. Originally designated the P-531-2, the Scout made its first flight in the summer of 1959 with a Blackburn A-129 engine derated to 635 s.h.p. instead of the Turmo which equipped the P-531 prototype. Later a Bristol Siddeley Nimbus 101/102 turbine replaced the Blackburn A-129 on an otherwise unchanged aircraft—the P-531-2 Mark 1 or Scout AH Mark 1, which became the production model, equipping the British Army Air Corps.

The Scout has a rotor with four blades of all-metal construction attached by the torsion-rod suspension system to the rotor head. The drag hinges are outboard of the flapping hinges, while friction-plate drag dampers are provided in addition to inter-blade snubbers. Auto-stabilization and auto-pilot systems form part of the Scout's equipment. The first Scout with hydraulic boost flew from March 1961 onwards.

The seating arrangements in this aircraft are designed for easy conversion to its various roles. Bench seats at the rear fold flat to leave space for freight or the carriage of two stretchers. The undercarriage consists of two skids.

This helicopter is used in large numbers by the British Army and is also in service with the survey ships of the Royal Australian Navy.

Engine: Bristol Siddeley Nimbus 101/102, derated to 685 s.h.p.
Length: (fuselage) 30 ft 7 in (9·32 m)
Width: 8 ft 4 in (2·54 m)
Height: 11 ft 3 in (3·43 m)
Rotor diameter: 32 ft 3 in (9·83 m)
Weight empty: 3,084 lb (1,399 kg)
Weight fully loaded: 5,300 lb (2,404 kg)
Cruising speed: 112 m.p.h. (180 k.p.h.)
max: 132 m.p.h. (212 k.p.h.)
Inclined climb: 1,660 ft/min (506 m/min)
Service ceiling: 17,000 ft (5,182 m)
Range: 275 miles (443 km)
Number of seats: 5

1960 WASP

The Wasp is the Naval version of the Scout. Its main duties are as an all-weather, anti-submarine helicopter able to operate from small platforms on frigates and destroyers.

The Wasp came into being through trials of a P-531 by the Royal Navy aboard H.M.S. *Undaunted* in November 1959. Since this helicopter is intended to be on standby on a flight deck much closer to sea-level than on a conventional aircraft-carrier, the undercarriage is the main problem to be solved. A system including four suction pads was first investigated, but in view of its complexity it was discarded for an undercarriage with a shock-resisting structure to which are fitted four fully-castoring or lockable wheels and incorporating devices that ensure rapid and secure fastening to the deck.

While in general the Wasp resembles the Scout, it has nevertheless some external differences such as the folding tail-rotor boom for easy shipboard stowage. It also has only half a tailplane on the starboard side. Additionally it has a two-stage collective pitch system, highly efficient when the rotor starts or stops on deck in high winds.

The Wasp AS Mark 1 prototype flew for the first time at the end of October 1962. The Wasp's turbine is derated to 710 s.h.p.

Wasp helicopters are in service with the Royal Navy, South African Navy, Netherlands Navy and in Brazil.

Engine: Bristol Siddeley Nimbus 103/104, derated to 710 s.h.p.
Length: (fuselage) 30 ft $5\frac{5}{8}$ in (9·59 m)
Width: 8 ft 8 in (2·64 m)
Height: 9 ft 9 in (2·97 m)
Rotor diameter: 32 ft 3 in (9·83 m)

WASP

Weight empty: 3,418 lb (1,550 kg)
Weight fully loaded: 5,500 lb (2,495 kg)
Cruising speed: 100 m.p.h. (161 k.p.h.)
Inclined climb: 1,140 ft/min (347 m/min)
Service ceiling: 12,500 ft (3,810 m)
Range: 305 miles (491 km)
Number of seats: 5

1964 SIOUX

From 1964–5 Westland started to manufacture under licence a light three-seater helicopter designed for the British Army Air Corps: the Agusta-Bell 47G-3B-1 Superalpino, known in the United Kingdom as the Sioux. The first Sioux built by Westland flew in March 1965. (For technical details see Bell, under United States of America.)

1967 WG-13

At the end of 1967 an agreement was reached between Westland and the French firm Sud Aviation regarding the latter's SA-330 and SA-340 and also the development by Westland of the WG-13, a twin gas-turbine helicopter to meet the joint requirements of the British and French services. The WG-13, fitted with a four-bladed rigid rotor, is intended in due course to replace the Scout and the Wasp.

The WG-13 is intended to fulfil a variety of roles including armed reconnaissance, search and rescue, casualty evacuation, communications, light transport, and so on. A full size mock-up was exhibited at the 1969 Paris Air Show.

Engines (2)*:* Rolls-Royce BS 360–07
Length: 38 ft 3¼ in (11·67 m)
Height: 11 ft 3 in (3·43 m)
Rotor diameter: 42 ft (12·8 m)
Weight empty: 4,347 lb (1,972 kg)
Weight fully loaded: 8,000 lb (3,269 kg)
Inclined climb: 2,650 ft/min (810 m/min)
Range: 470 miles (756 km)
Number of seats: 11

Hungary

At the time when Hungary together with Austria constituted the empire of Austro-Hungary, which was Germany's ally in World War I, a remarkable method of directing artillery fire was worked out by Theodor von Karman and Stefan Petroczy in the form of a captive helicopter to replace the traditional captive balloon.

PETROCZY–VON KARMAN

In 1915, during World War I, Lieutenant Stefan Petroczy, chief instructor for balloon crews at the Austro-Hungarian Ministry of War, and Professor Theodor von Karman (who after World War I went to the U.S.A., where he became a most eminent technician) set to work on the problem of replacing observation balloons by helicopters.

Von Karman's first trials were with small-scale models powered by a twisted rubber band, then with a larger aircraft weighing some 66 pounds (30 kilos) and driven by a 5 h.p. compressed-air engine. The purpose of these tests was to determine the best way of attaching the cables to ensure stability with a system of two contra-rotating co-axial rotors. Development work on the blades was done by von Asboth, a Hungarian.

The first aircraft built drew its power from a 200 h.p. electric motor, but the latter overheated so much that the design was abandoned. (This electric motor idea was also investigated in 1918 by Letourneur in France, and revived in 1940 in Germany by AEG for its tethered helicopter.)

The second Petroczy–von Karman design had three Le Rhône 120 h.p. rotary engines placed one on each of the three arms to which the cables of the mooring gear were attached. These engines drove two wooden contra-rotating co-axial rotors 20 feet (6·1 metres) in diameter, which turned at 600 r.p.m. With its overhead post for the artillery fire observer, the aircraft weighed 2,899 pounds (1,315 kilos).

After some fifteen ascents, during one of which a height of more than 130 feet (40 metres) was reached, this 'captive'-type helicopter was destroyed on landing on 10 June 1916.

VON ASBOTH

As early as 1908 von Asboth had set about building a biplane, and during

World War I he was Director of the Austro-Hungarian State Propeller Factory. He worked alongside von Karman, and in particular was responsible for the development work on the rotors for the Petroczy–von Karman helicopter.

Between 1928 and 1931, now working in Budapest, von Asboth tested various contra-rotating co-axial two-bladed rotors only 14 feet $3\frac{1}{4}$ inches (4·35 metres) in diameter.

Stability was achieved in the helicopters on which they were used by the action of the air which the rotors directed on to six mobile surfaces round the horizontal hinges. These six 'deflectors' were operated by the pilot, using traditional aircraft controls.

The fourth model, known as AH-4, had, instead of a Le Rhône 110 h.p. rotary, a Clerget 130 h.p. engine, which drove not only the rotors but also a tractor propeller. This rotorcraft in flying condition weighed 904 pounds (410 kilos), and could climb at a rate of 6 feet $6\frac{3}{4}$ inches (2 metres) per second. During its tests, it proved stable but hard to handle. It reached a height of over 98 feet (30 metres).

About 1930 two missions, one British, the other French, went to Budapest to check up at first hand on the results claimed by von Asboth. An expert in the British mission named Liptrot climbed to a height of 102 feet (31 metres), and flew for a distance of 3,000 yards (2,743 metres). Von Asboth completed his research, which was particularly concerned with his rotor system, the blades of which contained a movable part extending from the hub to the middle of the blade, and a fixed part from the middle to the tip, and then went to England, where the Blackburn Company became his licensee.

Italy

Italy's first contribution to rotorcraft development was a small-scale model built in 1877 by Professor Forlanini. It flew for twenty seconds, and fifty years were to go by before another Italian helicopter, made by Corridino d'Ascanio, became airborne.

AGUSTA

The company known as 'Costruzioni Aeronautiche Giovanni Agusta' is one of Europe's aviation pioneers—it was set up in 1907 by Giovanni Agusta. During and immediately after World War I the firm widened its scope and experience and finally established itself in 1923 at Cascina Costa. Before World War II it was mainly engaged in building under licence the Romeo 41, a single-seater fighter trainer for the Regia Aeronautica.

After World War II the aeronautical department became dormant and in 1946 the firm set up a subsidiary to manufacture MV-Agusta motorcycles. Aircraft work was resumed in 1950 with an order for the pre-war RO-41 trainer. In 1952, the Company obtained the co-operation of a designer named Zappata for fixed-wing aircraft and also embarked upon helicopter production through a licensing agreement with the American firm, Bell Aircraft Corporation. The first Bell 47 built by Agusta made its maiden flight on 22 May 1954. Production delivery started in January 1955. Since then helicopters made under licence by Agusta have been marketed not only in Europe but also in various North African, Far Eastern and Latin American countries.

Agusta has additionally been engaged on research and development work for new models including a three-turbine helicopter. Along with Westland and Sud Aviation, it is one of the largest helicopter producers in Western Europe. Towards the end of 1964, i.e. after just ten years' work in this field, Agusta delivered its thousandth helicopter.

In 1965, Agusta entered into far-reaching agreements with the American firm of United Aircraft in connection with rotary-wing aircraft. A licensing agreement has been signed with Sikorsky to build twenty-four SH-3D (S-61) helicopters for the Italian Navy.

Agusta's output falls into two main parts:

(1) Helicopters manufactured under licence from Bell:
Agusta-Bell 47G

Agusta-Bell 47J
Agusta-Bell 204B (UH-1B)
Agusta-Bell 205 (UH-1D)
Agusta-Bell 205TA
Agusta-Bell 206A (Jet Ranger)
Agusta-Bell 212

(2) Helicopters manufactured to original Agusta designs:
Agusta 101
Agusta 102
Agusta 103
Agusta 104
Agusta 105
Agusta 106
Agusta 109
Agusta 115

1954 AGUSTA-BELL 47G

This, with the exception of the flying instruments, was a replica of the Bell 47G.

Under this serial heading Agusta produced the following models: 47G-2 from 1955; 47G-2A in 1963; 47G-3 in 1960 and also the 47G-3B (OH-13S) and the 47G-3B-1 (TH-13T); 47G-4 in 1964 and later 47B-5. The G-3B-1, Superalpino, was ordered by the British Army in 1964. Part of the order was carried out under licence by Westland.

For technical details see under Bell 47G in the U.S.A. chapter.

1957 AGUSTA-BELL 47J

Under this serial name Agusta brought out from 1961 onwards the following models: 47J-2A, 47J-3 and 47J-3B-1, a high-altitude version of the 47J, developed by Agusta.

1961 AGUSTA-BELL 204B

This medium-sized helicopter, completed in May 1961, is now mass-produced for both commercial operators and the armed forces of Italy and other countries. With help from Bell, Agusta has also developed a version known as the ASW.

The Agusta-Bell 204B is powered by a Bristol Siddeley Gnome H.1200. It may eventually be equipped with a Lycoming T53L-11 or a General Electric T58-3 turbo engine. Plans have also been made for a more powerful engine such as the Gnome H.1400, the T58-10 or the T53L-13.

The standard rotor has a diameter of 48 feet (14·63 metres), but on request its size can alternatively be 44 feet (13·41 metres).

AGUSTA-BELL 204B

1964 AGUSTA-BELL 205

The 205, an enlarged variant of the 204, is equivalent to the Bell UH-1D.

The standard version is powered by a Lycoming T53-L-11 engine, providing a maximum of 1,100 h.p. at take-off. Either a Gnome H.1200 or a General Electric T58-3 engine can be fitted.

1965 AGUSTA-BELL 205TA

This is a twin-engined experimental prototype of the 205 that can still fly even if one engine is out of use. Use of each engine separately gives a normal endurance with no reserve of 6 hours 2 minutes as against 4 hours 24 minutes with both used together. Both are so used only for hovering or take-off and landing.

The first version of this twin-engined helicopter has two Turboméca Astazou X engines for a driving assembly coupled with a common reduction gear.

During the 1967 Le Bourget Show, Agusta exhibited an Agusta-Bell 205 two-turbine helicopter equipped with two Gnome H.1200 engines. This twin-version 205 was a development of the 205TA. Use of this power-plant necessitated a specially developed coupling gearbox and increased the gross weight by 1,000 pounds (454 kilos).

The latest version, the Agusta-Bell 212, is very similar to the 205. The

power plant consists of two turbines 'Turbo Twin-Pac' PT6T-3 with a total power of 1,800 s.h.p. used at a derated maximum power of 1,100 s.h.p.

1966 AGUSTA-BELL 206A JET RANGER

This helicopter is the Bell Jet Ranger modified in three different ways: as an executive helicopter, as an amphibious version with fixed floats, and as a military version.

The following helicopters have been built by Agusta to its own original designs.

1958 AGUSTA 101G

The birth of this heavy-duty helicopter goes back to about 1958, when the project was known as the AZ-101G, with the Z standing for the aeronautical engineer Zappata. Since this was initially a private venture, financial difficulties delayed completion. The maiden flight from Cascina near Gallarate did not take place until 19 October 1964, after one year of ground testing. In that same year a pre-line production order was given by the Italian Government.

The 101G, powered by three turbines and intended both for civil and military use, is in some ways akin to the Super Frelon of the French company Sud Aviation.

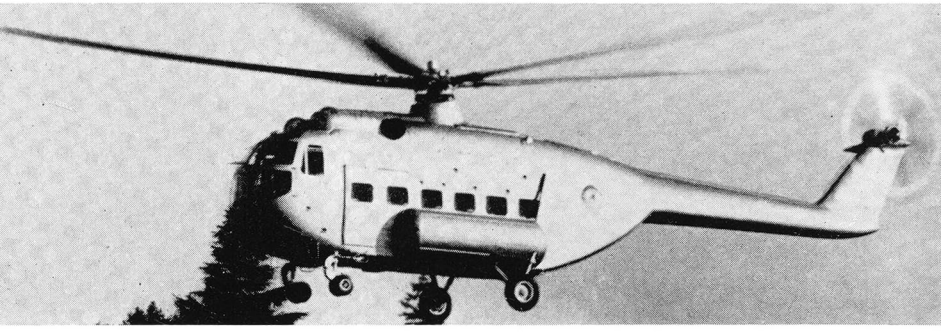
The cabin, which measures internally 16 feet $4\frac{7}{8}$ inches × 8 feet $2\frac{3}{8}$ inches × 6 feet $2\frac{1}{4}$ inches (5 × 2·5 × 1·9 metres), can take an average-sized truck; the helicopter can also lift $6\frac{1}{2}$ tons. Freight loading is facilitated by nose doors and a rear-ramp platform. Special provision is made for unusual loads taking up more than the helicopter's entire length: it can fly with the rear and front doors open.

In the passenger configuration the 101G can carry as many as thirty-five persons plus 1,543 pounds (700 kilos) over a range of 249 miles (400 kilometres). The ambulance version can carry eighteen patients on stretchers and up to six medical attendants. An anti-submarine version is also under development.

Various turbines can be used on the A-101G. Among them are the General Electric T58-10 or the Bristol Siddeley Gnome. The rotor is composed of a central hub in an oil bath which sustains the vertical and horizontal hinges of the five blades. The latter, all-metal, are individually interchangeable.

Engines (3): Gnome H.1400
Length: 53 ft 9 in (16·38 m)
Width: 14 ft $5\frac{1}{4}$ in (4·4 m)
Height: 16 ft $2\frac{1}{2}$ in (4·94 m)
Rotor diameter: 65 ft $3\frac{3}{8}$ in (19·9 m)
Weight empty: 14,000 lb (6,350 kg)

Weight fully loaded: 28,385 lb (12,875 kg)
Cruising speed: 130 m.p.h. (210 k.p.h.)
Inclined climb: 1280 ft/min (390 m/min)
Service ceiling: 12,139 ft (3,700 m)
Range: 252 miles (405 km)
Number of seats: 35



AGUSTA 101G

1959 AGUSTA 102

This Agusta 102 is a Bell 48 redesigned as a utility helicopter. It made its maiden flight in February 1959 using a Bell rotor system. Agusta developed it to carry passengers, freight or four stretchers when used as an ambulance. A few production machines have been built.

Engine: Pratt and Whitney R-1340-55, 600 h.p.
Length: 41 ft $9\frac{1}{4}$ in (12·73 m)
Width: 7 ft $2\frac{5}{8}$ in (2·2 m)
Height: 10 ft $7\frac{1}{8}$ in (3·23 m)
Rotor diameter: 47 ft $6\frac{3}{4}$ in (14·5 m)
Weight empty: 3,968 lb (1,800 kg)
Weight fully loaded: 6,283 lb (2,850 kg)
Cruising speed: 99 m.p.h. (160 k.p.h.)
Ceiling: 14,009 ft (4,270 m)
Range: 3 hrs 20 min (endurance)
Number of seats: 9

1959 AGUSTA 103

This prototype of a single-seat ultra-light helicopter is powered by a flat 4-cylinder Agusta engine and has a Bell-type rotor. It flew for the first time in October 1959.

Engine: A-70V, 85 h.p.

Rotor diameter: 24 ft 3 in (7·39 m)
Weight empty: 583 lb (264·5 kg)
Weight fully loaded: 1,055 lb (478·5 kg)
Cruising speed: 75 m.p.h. (120 k.p.h.)
Inclined climb: 787 ft/min (240 m/min)
Range: 155 miles (250 km)
Number of seats: 1

1960 AGUSTA 104

Known as the Helicar, this helicopter is derived from the 103 and, like it, has not advanced beyond the prototype stage. It made its maiden flight in December 1960. It uses an Agusta engine derated from 140 h.p. to 120 h.p.

Engine: A-140V, 120 h.p.
Length: 20 ft 10 in (6·35 m)
Height: 7 ft 8½ in (2·35 m)
Rotor diameter: 26 ft 1 in (7·95 m)
Weight empty: 838 lb (380 kg)
Weight fully loaded: 1,411 lb (640 kg)
Cruising speed: 84 m.p.h. (135 k.p.h.)
Inclined climb: 13½ ft/sec (4·1 m/sec)
Range: 205 miles (330 km)
Number of seats: 2

1962 AGUSTA 115

This helicopter retains the main and tail-rotor assemblies of the Agusta-Bell 47J-3 but it is powered by an Astazou turbine. The power transmission consists of a reduction gearbox provided with a centrifugal clutch attached to the engine forward flange. A vertical articulated shaft drives the main transmission. There are two side-by-side pilots' seats and two passenger seats.

Engine: Turboméca Astazou II, 480 s.h.p.
Length: 32 ft 5¾ in (9·9 m)
Height: 9 ft 7¾ in (2·94 m)
Rotor diameter: 37 ft 2 in (11·33 m)
Weight empty: 1,609 lb (730 kg)
Weight fully loaded: 2,976 lb (1,350 kg)
Cruising speed: 93 m.p.h. (150 k.p.h.)
Service ceiling: 15,584 ft (4,750 m)
Range: 162 miles (260 km)
Number of seats: 4

1964 AGUSTA 105

This light turbine-powered, all-purpose helicopter was developed from

the Agusta 104. It has two seats and furthermore two platforms on each side of the centre part of the fuselage to carry either freight or four men over short distances.

It is powered by a Turboméca Astazou of which Agusta built the turbine front section, the reducing gear and the rotor hydraulic-friction-drive system.

The Agusta 105 made its maiden flight during the autumn of 1964.

Engine: Turboméca Agusta TA-230, derated to 270 s.h.p.
Length: 22 ft $0\frac{5}{8}$ in (6·72 m)
Height: 7 ft $11\frac{1}{4}$ in (2·42 m)
Rotor diameter: 27 ft $6\frac{3}{4}$ in (8·4 m)
Weight empty: 1,069 lb (485 kg)
Weight fully loaded: 2,205 lb (1,000 kg)
Cruising speed: 112 m.p.h. (180 k.p.h.)
Inclined climb: $13\frac{1}{2}$ ft/sec (4·1 m/sec)
Ceiling: 15,748 ft (4,800 m)
Range: 199 miles (320 km)
Number of seats: 2

1965 AGUSTA 105B

This direct development of the Augusta 105 is an all-purpose four-seater helicopter suitable for both military and civilian use.

Engine: Turboméca Agusta TA-230, derated to 270 s.h.p.
Weight empty: 1,323 lb (600 kg)
Weight fully loaded: 2,756 lb (1,250 kg)
Maximum speed: 130 m.p.h. (210 k.p.h.)
Range: 304 miles (490 km)
Number of seats: 4

1966 AGUSTA 106

This is a single-turbine helicopter for special military applications developed under contract with the Italian Government. It was first shown in public at the Le Bourget Show in June 1967. The single-seater helicopter has a foldable two-bladed rotor and a special device for folding the tail section. In its Naval version, it carries two torpedoes.

Engine: Turboméca Agusta TAA-230, 350 s.h.p.
Length: (fuselage) 22 ft $7\frac{5}{8}$ in (6·9 m)
Width: 6 ft 2 in (1.88 m)
Height: 8 ft $2\frac{3}{8}$ in (2·5 m)
Rotor diameter: 31 ft 2 in (9·5 m)
Weight empty: 1,301 lb (590 kg)
Weight fully loaded: 2,998 lb (1,360 kg)
Cruising speed: 114 m.p.h. (185 k.p.h.)
max: 124 m.p.h. (200 k.p.h.)

Rate of climb: 1,201 ft/min (366 m/min)
Range: 174 miles (280 km)
Number of seats: 1

1965 AGUSTA 109 (PROJECT)

This medium-capacity, high-performance, seven-seater prototype was originally built with a Turboméca Astazou XII, but it may be fitted with an Astazou X, a Pratt and Whitney, or other turbines of about 700 s.h.p. The main rotor has four, the tail rotor two blades, all made entirely of metal. The main drive is by conical and cylindrical gears.

The undercarriage consists of three wheels of which the front can be retracted into the fuselage and the two main ones into side grooves.

This project has given rise to variants: the 109B, a medium tactical-support helicopter equipped with two Continental T67-T-1 turbines each of 770 s.h.p. at take-off, and the 109C, a passenger transport with two Allison 250-C-14 turbines.

Engine: Turboméca Astazou XII
Length: 9 ft (2·74 m)
Height: 10 ft (3·05 m)
Rotor diameter: 36 ft 1 in (11 m)
Weight empty: 2,425 lb (1,100 kg)
Weight fully loaded: 5,291 lb (2,400 kg)
Cruising speed: 147 m.p.h. (237 k.p.h.)
Inclined climb: 1,409 ft/min (427 m/min)
Range: 311 miles (500 km)
Number of seats: 7

COSTRUZIONI ITALIANE ELICOTTERI

A helicopter designed as a road vehicle was exhibited by this firm at the 1964 Turin Exhibition. For road use it is equipped with a small two-stroke engine to drive one of the main wheels.

1964 CICOGNA ('STORK') C-1

This two-seater machine consists of a tubular structure with a two-bladed rotor and the exhibiting firm described it as 'a substitute for a car'. The engine for road use is a small 50 c.c. single cylinder. The main engine is a 100 h.p. 'Mercury' and the speed claimed is 62–75 m.p.h. (100–120 k.p.h.).

D'ASCANIO

In October 1930, d'Ascanio set up the following world records for helicopters:

Altitude: 59 feet (18 metres)
Distance: 1,180 yards (1,078 metres)
Endurance: 8 minutes 45 seconds

D'Ascanio's helicopter was fitted with two two-bladed co-axial contra-rotating rotors. The blades were free to flap up and down and were mounted on a horizontal hinge. A small tailplane on the tip of the blades acted as a stabilizer and an elevator operated from the cockpit was used to change their pitch.

There were in addition three small variable-pitch airscrews: two were horizontal, one on the side for lateral, one at the tail for longitudinal, control. The third was vertical to provide yaw control.

The two rotors and the three airscrews were powered by a Fiat 95 h.p. A-50 engine. The aircraft's total weight was 1,764 pounds (800 kilos). Its successful flight led to its being acquired by the Italian Air Ministry.

D'ASCANIO 1930

DOMAN-AMBROSINI

In 1960, under its President, Ambrosini, the firm Aeronautica Sicula of Palermo in Sicily intended to build in small numbers the Doman LZ-5, an American aircraft going back as far as 1953, which had found no outlet

in the United States and Canada. The Ambrosini version would have included a certain number of improvements.

1961 DOMAN-AMBROSINI D-10B

In outward appearance this aircraft resembled the Doman LZ-5, which was given an F.A.A. certificate. The D-10B also retained the Doman's hingeless-rotor gimbal-mounted hub end.

Engine: Lycoming, 400 h.p.
Length: (fuselage) 38 ft (11·58 m)
Height: 10 ft 5 in (3·18 m)
Weight empty: 3,373 lb (1,530 kg)
Weight fully loaded: 5,545 lb (2,515 kg)
Cruising speed: 98 m.p.h. (158 k.p.h.)
Range: 730 miles (1,175 km)
Number of seats: 8

FIAT

This firm, best known as Italy's largest motor-car manufacturer, also has an aircraft department. In 1958 for the first time it conducted studies of a medium-sized, general-purpose helicopter centred on a gas-turbine engine built to the orders of M.W.D.P. and the Italian Air Defence Ministry.

1958 FIAT 7002

The rotor is driven by jets of compressed air from the ends of the blades. These are 'cold-type' jets, since no fuel is burnt in the compressed air driving the rotor. The compressed air is supplied by a Fiat 4700 turbo-generator, with the turbine of the compressor unit powered by a hot-gas generator or a primary motor using almost all the component parts of the Fiat 4002 turboreactor.

Despite the absence of any torque effect, the helicopter has been fitted with a small tail-buoyancy rotor mechanically linked with the main rotor to ensure perfect manœuvrability at low horizontal speeds.

The engine is placed vertically in the rear part of the fuselage, which is made of light alloy. The fuselage centre contains the fuel reservoirs and the freight space; above it rests the rotor hub. The front part houses the cockpit with dual controls. The helicopter can carry in addition to the pilot either six passengers, two stretchers and an orderly, or freight with a volume of up to 87 cubic feet (2·5 cubic metres).

The maiden flight took place at Caselle aerodrome near Turin on 26 January 1961, but no subsequent development work has been done.

Engine: Turbogenerator Fiat 4700, 540 s.h.p.
Length: (fuselage) 20 ft 1 in (6·12 m)

Width: 6 ft $6\frac{3}{4}$ in (2 m)
Height: 9 ft $5\frac{1}{2}$ in (2·88 m)
Rotor diameter: 39 ft 4 in (12 m)
Weight empty: 1,488 lb (675 kg)
Weight fully loaded: 3,086 lb (1,400 kg)
Cruising speed: 85 m.p.h. (137 k.p.h.)
Service ceiling: 11,155 ft (3,400 m)
Range: 190 miles (306 km)
Number of seats: 7

ISACCO

Further developmental work in the rotary-wing field done by an Italian, though not in Italy, came from Vittorio Isacco, an engineer who for some time worked with the Spaniard, Pescara (*q.v.*).

Isacco's 'Helicogyro' had a two-bladed rotor, which was made to turn by an engine-airscrew assembly located on the tip of the blades. A third engine, in the nose, provided horizontal movement in the conventional manner.

As far back as 1929 one form of this 'Helicogyro' was tried in the United Kingdom. It had a Bristol Cherub 32 h.p. engine at the tips of a rotor 41 feet (12·5 metres) in diameter. The machine had great difficulty in lifting from the ground its weight of 1,235 pounds (560 kilos).

No better success was obtained from another version powered by four Bristol Cherub engines at the tips of a four-bladed rotor with a diameter of 49 feet 2 inches (15 metres). Not only was the weight—2,400 pounds (1,089 kilos)—too high, but centrifugal force effects produced countless difficulties in the feeding and running of the engines.

In 1932 Isacco started to build a giant 'Helicogyro' in collaboration with Izakson at the Civil Aviation Institute in Moscow. Four De Havilland 120 h.p. engines were mounted on the tips of the four blades of a rotor 90 feet (27·43 metres) in diameter. The engine in the nose was a 300 h.p. Wright. The total weight was 7,000 pounds (3,175 kilos). In 1935, when this 'Helicogyro No. 4' was completed but had not undergone any trials, Isacco left Russia.

Latterly, still in the rotary-wing field, he has worked, particularly in France, on 'rotachutes' fitted with telescopic blades.

Isacco had previously been given some demonstrations of his telescoping rotor blades at Boreham aerodrome, Essex, England. His system, loaded on to a lorry body on a special tubular stand, consisted of Duralumin blades 2 feet (61 centimetres) long, which could extend to form a rotor 18 feet (5·49 metres) in diameter with a total weight of about 25 pounds (11·5 kilos).

The lorry carrying the assembly drove down the airfield runway and when a speed of 30 m.p.h. (48 k.p.h.) was reached, Isacco pressed a release button and in a few seconds the blades were completely extended.

Isacco's view was that telescoping blades could act as a safety device to replace the conventional parachute, since the blades of the rotor-parachute would open automatically by centrifugal force. Various tests were also carried out at the Centre d'Essais en Vol (Flying Test Centre) at Brétigny in France.

A rotor larger than the one tested could have been fitted to the roof of an expendable cabin in a transport aircraft and be used in case of emergency. The same method could also have been applied, for instance, to reduce an aircraft's landing speed.

LUALDI

Aer-Lualdi, with works situated near Udine, came into being in 1953 and first built an experimental helicopter designated ES-53. This was fitted with the American Hiller Rotormatic control supplemented by a Lualdi gyroscope system designed to ensure easier flight. Successful trials led to the later building of improved prototypes.

1953 ES-53

This was a helicopter of traditional configuration with two-bladed main and tail rotors.

The main rotor is kept in equilibrium through a gyroscopic system patented by Lualdi and consisting of stabilizing weights attached by a flexible connection to each end of a small control rotor. There is thus one rotational plane of the control rotor and a virtual plane of gyroscopic stabilization. The control rotor is made of small 'paddles' like those in the Hiller helicopters. The rotor's maximum speed is 445 r.p.m.

The fuselage was made of welded steel tubes, and the boom was of the same construction with the engine carried above. The landing gear consisted of four wheels, two of which were at the end of struts starting from either side of the engine, and the other two forward of the pilot's compartment.

The first test flights were made at Campoformido aerodrome on 7 March 1954.

Engine: Continental, 85 h.p.
Length: 21 ft 6 in (6·55 m)
Height: 8 ft 6 in (2·6 m)
Rotor diameter: 23 ft 11⅜ in (7·3 m)
Weight empty: 728 lb (330 kg)
Weight fully loaded: 1,146 lb (520 kg)

Cruising speed: 62 m.p.h. (100 k.p.h.)
Range: 155 miles (250 km)
Number of seats: 1

1957 L-55

The acquisition of a licence from the Hiller Corporation for its Rotormatic system made it possible to design an entirely new helicopter with a fully streamlined fuselage and stressed-skin tailboom.
Engine: Lycoming, 180 h.p.
Length: (overall) 39 ft (11·9 m)
Diameter: 32 ft 10 in (10 m)
Weight empty: 1,323 lb (600 kg)
Weight fully loaded: 2,205 lb (1,000 kg)
Cruising speed: 81 m.p.h. (130 k.p.h.)
Inclined climb: 16½ ft/sec (5 m/sec)
Absolute ceiling: 13,123 ft (4,000 m)
Range: 3 flying hours

1957 L-57

This helicopter's engine is mounted in the nose ahead of the cockpit and the transmission passes through the enclosed cabin. See also L-59 below.

1959 L-59

Two prototypes of the L-59, which resembles the L-57 but has a more powerful Continental direct-injection engine, were built at the Aeronautica Varese factory. Each has a two-bladed main rotor of metal construction, built by Parsons, of the type fitted to the Hiller Model 360 cyclic pitch control of the Hiller Rotormatic type is provided together with a Lualdi gyro-stabilizer. Twin fuel tanks are placed above the cabin on each side of the rotor axis; the exhaust system is below the streamlined fuselage. One of these helicopters was sold early in 1961 to the Italian Army.
Engine: Continental, 260 h.p.
Length: (fuselage) 29 ft 9½ in (9·08 m)
Rotor diameter: 39 ft 9½ in (12·13 m)
Weight empty: 1,700 lb (771 kg)
Weight fully loaded: 2,690 lb (1,220 kg)
Cruising speed: 80 m.p.h. (129 k.p.h.)
Inclined climb: 899 ft/min (274 m/min)
Absolute ceiling: 14,009 ft (4,270 m)
Range: 3 flying hours
Number of seats: 4

L-59

MANZOLINI

Count Ettore Manzolini di Campoleone has financed and developed a series of helicopters with co-axial rotors. In the early stages he was helped in his research work by two engineers named Bordoni and Giannini. Later, the helicopters were developed under the aegis of the Compagnia Nazionale Aeronautica di Ettore Manzolini.

1953 LIBELLULA I

This light helicopter, embodying the results of Bordoni's experiments, was built with co-operation from Giannini. It had two co-axial, contra-rotating two-bladed rotors and made its maiden flight on 7 January 1952.

Engine: Hirth, 105 h.p.
Rotor diameter: 26 ft (7·92 m)
Weight fully loaded: 1,433 lb (650 kg)
Cruising speed: 65 m.p.h. (104 k.p.h.)
Number of seats: 1

1961 LIBELLULA II

This research and investigational work led to a co-axial light helicopter designated Libellula II, which was certificated by the Registro Aeronautico Italiano in October 1962.

The co-axial contra-rotating two-bladed rotors have blades attached semi-rigidly to the hub with offset drag hinges. The rotors are driven through reduction gear with separate gearboxes.

Engine: Walter Minor, 101 h.p.
Length: (fuselage) 15 ft 11 in (4·85 m)
Width: 6 ft 11½ in (2·12 m)
Height: 10 ft 0½ in (3·06 m)
Rotor diameter: 25 ft 6⅜ in (9 m)
Weight empty: 1,098 lb (498 kg)
Weight fully loaded: 1,433 lb (650 kg)
Cruising speed: 56 m.p.h. (90 k.p.h.)
Service ceiling: 9,514 ft (2,900 m)
Range: 124 miles (200 km)
Number of seats: 1

1962 LIBELLULA III

Four prototypes were built of this slightly bigger version of the Libellula II with a more powerful engine. The two side-by-side seats and co-axial two-bladed rotors were retained.
Engine: Rolls-Royce Continental O-300-C
Length: (fuselage) 16 ft 5 in (5 m)
Width: 8 ft 1½ in (2·48 m)
Height: 10 ft 7 in (3·23 m)
Rotor diameter: 32 ft 10 in (10 m)
Weight empty: 1,279 lb (580 kg)
Weight fully loaded: 1,874 lb (850 kg)
Cruising speed: 51 m.p.h. (82 k.p.h.)
Inclined climb: 984 ft/min (300 m/min)
Service ceiling: 7,710 ft (2,350 m)
Range: 155 miles (250 km)
Number of seats: 2

1964 LIBELLULA IV

This is a four-seater version of the Libellula III with two Rolls-Royce Continental O-300 engines, each of 145 h.p.
Engines (2)*:* Rolls-Royce Continental, 145 h.p. each
Length: (fuselage) 18 ft 0½ in (5·5 m)
Width: 8 ft 8 in (2·65 m)
Height: 10 ft 10 in (3·3 m)
Rotor diameter: 35 ft 5 in (10·8 m)
Weight empty: 2,425 lb (1,100 kg)
Weight fully loaded: 3,307 lb (1,500 kg)
Cruising speed: 81 m.p.h. (130 k.p.h.)
Inclined climb: 1,080 ft/min (329.2 m/min)
Ceiling: 13,123 ft (4,000 m)
Range: 224 miles (360 km)
Number of seats: 4

PIAGGIO

During the 1930s the Piaggio Company, which had been founded some ten years earlier, began to build medium and heavy bombers, some of them equipped with engines also made by the firm. In all, the company has turned out several thousand aircraft of various types, from the smallest single-seater to four-engined bombers.

In World War II the Piaggio P-108b, with a performance akin to that of the American Flying Fortress, was used on both the African and the Russian fronts, more particularly by the Mussolini Squadron, so called to commemorate the Duce's son, who lost his life testing a prototype of the bomber.

A more advanced version, the P-133, was being built at the time Italy made her armistice with the Allies.

Since World War II, Piaggio has gradually reverted to its aeronautical activities and has been particularly interested in developing the P-136, an amphibious flying-boat, and in helicopters.

1946 PD-3

This helicopter, on which much development work was done, had a three-bladed main rotor and a two-bladed tail rotor.

Engine: Alfa Romeo 115, 200 h.p.
Rotor diameter: 42 ft 8½ in (13·02 m)
Weight empty: 1,786 lb (810 kg)
Range: 186 miles (300 km)
Number of seats: 2

SIAI-MARCHETTI

As far back as 1915 this Company built the first seaplanes for the Italian Navy. Between the wars it produced a series of aircraft which set up a number of world records. Among these aircraft must be mentioned the military types SM-79 and SM-82. The Company's present interest is mainly the construction of passenger and freight cars for the Italian State Railways. It is also concerned with light aviation and during 1964 it started work on its first helicopter, jointly with Silvercraft.

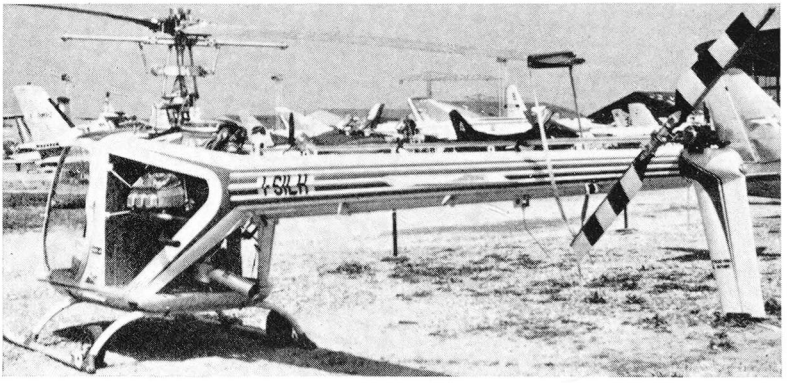
At the end of 1968, Silvercraft S.P.A. took over the responsibility for production of the SH-4 helicopter.

1964 SH-4

This prototype of a light two-seater helicopter of clean, aerodynamic design is suitable for training, liaison and agricultural applications. The two-bladed wooden rotor is of the Bell type and driven by a derated reciprocating engine specially positioned for easy maintenance.

In 1966 the control system was improved so that the gyro-stabilizing bar on the rotor head was no longer essential. The helicopter is produced in two versions: one for passenger transport, one for agricultural use.

Engine: Franklin 6A-350-D, 235 h.p.
Length: 25 ft 1⅛ in (7·65 m)
Width: 5 ft 8½ in (1·74 m)
Height: 9 ft 9½ in (2·98 m)
Rotor diameter: 29 ft 7½ in (9·03 m)
Weight empty: 1,124 lb (510 kg)
Weight fully loaded: 1,900 lb (862 kg)
Cruising speed: 87 m.p.h. (140 k.p.h.)
max: 100 m.p.h. (161 k.p.h.)
Rate of climb: 1,148 ft/min (350 m/min)
Service ceiling: 13,123 ft (4,000 m)
Range: 186 miles (300 km)
Number of seats: 3



SIAI-MARCHETTI SH-4

Japan

FUJI

Fuji Heavy Industries, set up in 1953, succeeded the Nakajima Aircraft and under licence started to build American trainers for the Japanese and the Philippine Air Forces. Later, in 1962, Fuji began to build, still under licence, the Bell 204B with a Lycoming T53-L-9 shaft turbine (see Bell 204B in the chapter on the U.S.A.).

HAGIWARA

Hisao Hagiwara had earlier been conducting experimental work into the propulsion of helicopters by pulse-jet and ram-jet engines under the aegis of Jiyu Koku Kenkyusho (the Freedom Aeronautical Research Institute of Tokyo).

When that body was disbanded in 1957, he continued the experiments on his own.

1955 JHX-3

After several test-bed runs, ram-jet engines were successfully tried out on an experimental helicopter in 1955. The rotor was started by the use of compressed air.

1958 JHX-4

This single-seater ram-jet helicopter with conventional controls was launched on its test programme in September 1958.

KAWASAKI

Kawasaki Kokuki Kogyo K.K. was originally a department of the great Kawasaki dockyard shipbuilding establishment before it became the Kawasaki Engineering Company Ltd. As such, it was one of the world's largest military aircraft manufacturers both prior to and during World War II.

As from 1928 Kawasaki designed its own aircraft, and from 1932 onwards its Type 92 fighter was mass-produced with engines also built by Kawasaki under licence from the Bayerische Motorenwerke (BMW).

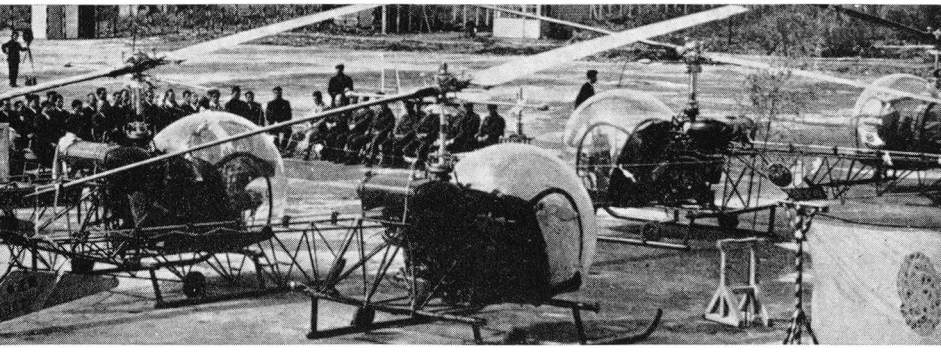
Among the long series of aircraft with which Kawasaki supplied the Japanese Army Air Force, mention may be made of the Ki-61, certain versions of which flew at more than 350 m.p.h. (563 k.p.h.), the Ki-100, a mainland defence aircraft, the twin-engined Ki-45, widely used on the Pacific theatres during World War II, the Ki-48 dive-bomber, and also guided missiles with a warhead containing 660 pounds (300 kilos) of explosives.

The Kawasaki factories, heavily damaged by Allied bombing, were split up after World War II into two divisions: Kawasaki Gifu, engaged in overhauling American aircraft and in building trainers of Japanese design or American origin under licence, and Kawasaki Kikai, which concentrated on engines.

From 1954 onwards Kawasaki built under licence a small number of United States Bell aircraft such as the Kawasaki-Bell 47D and later the Bell 47G-2A as well as the four-seater KH-4, which was a development of Bell 47G-3B, in which the cabin had been redesigned to take an additional person.

Kawasaki also has an agreement with Boeing Vertol for the assembly of the KG-107-II, i.e. the Boeing Vertol 107-II.

The latest licence in which Kawasaki has shown interest relates to the Hughes OH-6A.



KAWASAKI-BELL 47D

KAYABA

Prior to World War II the K. K. Kayaba Seisakusho (Kayaba Industrial Company) had specialized in aircraft components and especially oleo landing-gear systems.

In 1938 Shiro Kayaba, founder of the firm, undertook to carry out tests

on tailless gliders designed in accordance with principles laid down by Kumazo Hino, one of the pioneers of aviation in Japan.

In 1939 Kayaba received from the Japanese Army Air Headquarters a Kellett KD-1A autogyro which had been damaged during trials. Kayaba repaired it and at the same time started to build his own two-seater autogyro which showed striking resemblances to the one under repair.

The Japanese version was used during World War II for anti-submarine work, and it later operated from the aircraft-carrier *Akitsu-Ma*. The first version was followed by several others.

In 1952 Kayaba started to build a 'convertible' working from a Cessna 170 fuselage.

1941 KA-1

While Kayaba was repairing the Kellett KD-1A provided by the Testing Division of the Japanese Army Air Headquarters, an autogyro on similar lines, the Ka-1, was built which incorporated a direct take-off system.

This two-seater, powered by a Kobe engine, which was in fact a German Argus AS-10C built under licence in Japan, could carry two 132-pound (60-kilo) bombs and was used in anti-submarine operations.

Engine: Kobe, 240 h.p.
Number of seats: 2

1942 KA-2

This version differed from its predecessor only in being powered by a different engine, a Jacobs L-4MA.

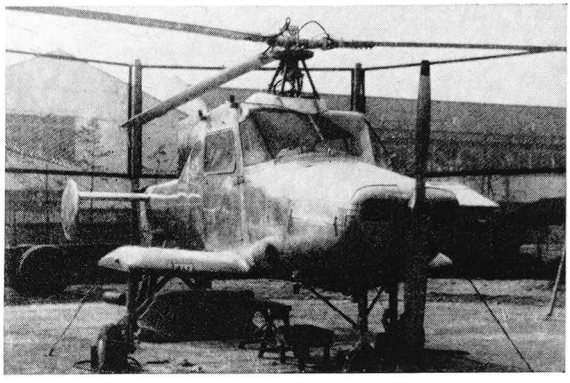
1952 KAYABA HELIPLANE

This prototype, designed in 1952 and given its tie-down tests in 1954, was built round the fuselage of a four-seater Cessna 170B light plane from which the high wing had been removed. Two low wings of 9-foot (2·74-metre) span were added. They also carried the two main wheels of the tricycle undercarriage.

The three-bladed rotor was mounted on a rotor pylon above the cabin, and three Ishikawajima ram-jets were fitted to the blade tips.

In horizontal flight the rotor revolved by auto-rotation and the aircraft was powered by an internal combustion engine driving a fixed-pitch two-bladed airscrew.

Engine: Continental E-180, 180 h.p.
Rotor diameter: 36 ft (10·97 m)
Number of seats: 4



HELIPLANE

MITSUBISHI

Before and during World War II Mitsubishi Heavy Industries was one of the major Japanese producers of bomber and reconnaissance aircraft. After the war it was given the task of completing the assembly of three hundred F-86F Sabres and subsequently production of F-104 Starfighters. In 1954 it took over responsibility for overhauling the S-55 owned by the U.S. Forces based in Japan. In 1958 Mitsubishi negotiated a licence to build the Sikorsky S-55 and later the S-61, S-62 and SH-3A. (For technical details see the entry under Sikorsky in the U.S.A. chapter.)

YOMIURI

1955 Y-1

This two-seater helicopter, for which an airworthiness certificate was granted by the Japanese authorities, was powered by a 7-cylinder radial engine. It had a two-bladed main rotor and the anti-torque rotor was carried at the tip of a boom made from an uncovered lattice structure.

Engine: Hitachi Jinphu III, 150 h.p.
Rotor diameter: 32 ft 10 in (10 m)
Cruising speed: 77 m.p.h. (124 k.p.h.)
max: 97 m.p.h. (156 k.p.h.)
Range: 199 miles (320 km)
Number of seats: 2

Netherlands

NEDERLANDSE HELICOPTER INDUSTRIE

This firm was set up to exploit patents held by an engineer, J. Meyer Drees, who had developed a helicopter powered by ram-jet engines at SOBEH, the abbreviated name of the Stichting voor de Ontwikkeling en Bouw van een Experimenteel Hefschroefvliegting: Foundation for the Development and Construction of an Experimental Helicopter.

This foundation, funds for which had been provided by K.L.M. (Royal Netherlands Airlines) and various Netherlands Ministries, owned a Sikorsky S-51 which they could all use for their specialized needs.

The foundation was liquidated in 1950, and the proceeds from the sale of the S-51 to the Royal Netherlands Navy were used to finance the SOBEH-1, the first post-World War II helicopter of Netherlands design and construction.

Later, the Nederlandse Helicopter Industrie, which was formed by Aviolanda and Kromhout, took over the rights relating to the SOBEH-1, and in 1956 started test work on a production model derived from the experimental prototype with ram-jet engines.

1954 NHI H-1

Advantage was taken by SOBEH of the investigations carried out by the National Luchvaart Laboratorium (National Aeronautical Research Institute) into a self-adjusting rotor in developing the H-1.

The rotor has an automatic regulation system based on the fact that the blades' centre of gravity is in front of their centre of lift. There is thus permanently in existence a couple tending to decrease the blades' angle of attack. Lift moment is controlled by torsion springs embodied in the control system.

The ram-jets placed at each tip of the two-bladed rotor were developed mainly by the National Luchvaart Laboratorium.

The ground tests lasted a long time and when the helicopter made its first flights in 1954 it was severely damaged by the ground resonance which was produced.

Data obtained from the H-1 were applied in building the H-2.

1955 NHI H-2

This was an improved version of the SOBEH experimental prototype.

Various changes were introduced, such as a small tail rotor for directional control and a large windscreen forward.

The H-2 first flew in May 1955.

1956 NHI H-3

This was the designation of the production model of the H-2 to be built by the Nederlandse Helicopter Industrie N.V.

Highly simplified construction was to be used: the two-bladed rotor had ram-jet engines giving roughly 100 h.p. at 500 r.p.m. The purpose of the small tail rotor was mainly to ensure the helicopter's directional manœuvrability. Stability was such that the pilot's hands might be taken completely off the controls in flight for up to four minutes at a time.

Range varied considerably according to the load carried. With only the pilot and a full load of fuel aboard endurance was one hour, but an additional load of 882 pounds (400 kilos) reduced it to fifteen minutes.

In December 1955, six months after construction started, the H-3 made its maiden flight.

Engines (2): TJ5A ram-jets, equivalent to roughly 100 h.p.
Length: 13 ft $1\frac{1}{2}$ in (4 m)
Height: 8 ft $5\frac{1}{8}$ in (2·57 m)
Rotor diameter: 34 ft 8 in (10·57 m)
Weight empty: 441 lb (200 kg)
Weight fully loaded: 1,433 lb (650 kg)
Cruising speed: 50 m.p.h. (80 k.p.h.)
max: 75 m.p.h. (120 k.p.h.)
economic: 31 m.p.h. (50 k.p.h.)
Number of seats: 2

VON BAUMHAUER

Between 1925 and 1930 much interest was aroused in the Netherlands by A. G. von Baumhauer's aircraft, built under the auspices of the Netherlands Government.

1930 VON BAUMHAUER

Von Baumhauer's helicopter differed from most of its contemporaries in using only a single rotor with two blades 49 feet $10\frac{1}{2}$ inches (15·2 metres) in diameter, turning at about 100 r.p.m. and driven by a 200 h.p. BR-2 rotary engine.

Stability was obtained by a blade-warping system, similar to that used by Pescara.

Torque was compensated for in the same way as on modern mechanical-drive helicopters with only one main rotor, that is by an anti-torque rotor

placed at the tail of the fuselage. The anti-torque airscrew was powered by a Thulin 80 h.p. rotary engine distinct from the main one.

This rotorcraft when finished in 1930 weighed 2,866 pounds (1,300 kilos). It successfully flew a short distance, but failed to achieve any practical results, since a broken blade ended the experiments.

Norway

Since World War II only one rotorcraft has made its appearance in Scandinavia, the helicopter designed by Kjölseth in Norway.

KJÖLSETH

During his spare time, Lieutenant-Colonel P. Kjölseth of the Royal Norwegian Air Force developed and built a helicopter of standard design. The first successful test flights took place in 1956. A few years later the traditional piston engine was dropped in favour of a turboshaft engine.

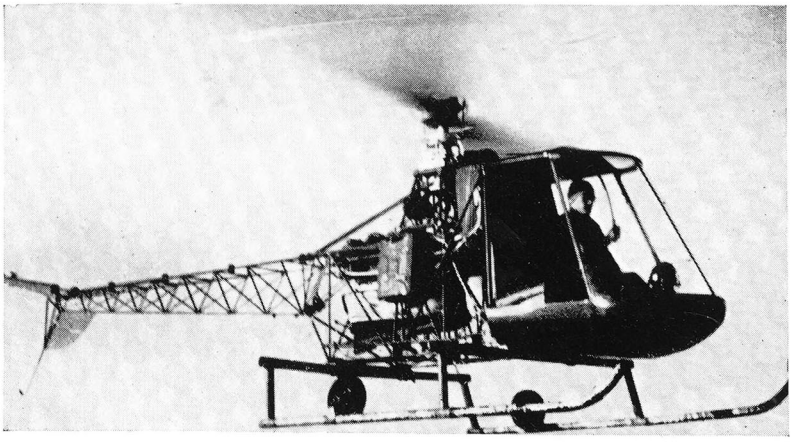
1956 KJÖLSETH

This two-seater helicopter had a two-bladed rotor driven by a horizontal-crankshaft engine, situated behind the cabin. The rotor blades were made of laminated wood covered with glass fibre cloth, and the leading edge was covered with stainless steel sheet.

Paul Kjölseth fitted a second prototype evolved by him with a General Electric T58 turboshaft engine. It flew successfully from 1960 until February 1965, when it crashed during a demonstration flight.

Engine: Ranger 6-440C-4, 180 h.p.

Length: (overall) 37 ft $4\frac{1}{8}$ in (11·38 m)



KJÖLSETH

Width: (fuselage) 3 ft 11¼ in (1·2 m)
Height: (overall) 8 ft 2⅝ in (2·5 m)
Rotor diameter: 30 ft 4⅝ in (9·26 m)
Weight empty: 1,378 lb (625 kg)
Number of seats: 2

Poland

GLOWNY INSTYTUT LOTNICTWA

The Glowny Instytut Lotnictwa in Warsaw is Poland's leading aeronautical institute in the fields of research and testing. In 1946 it began developmental work on a glider and a type of helicopter. Three years later the GIL helicopter, taking its name from the institute's initials, made its first test flights.

1949 GIL

This orthodox helicopter had a two-bladed rotor mounted on a universal joint, and a small ancillary rotor with servo-blades to regulate cyclic pitch and ensure stability in the main rotor. The latter was located immediately above the engine.

The anti-torque tail rotor was placed at the end of a monocoque boom made of plywood.

Bronislaw Zurakowski, one of its designers, acted as test pilot during the early trials.

Engine: Hirth, 100 h.p.
Length: 27 ft 10⅝ in (8·5 m)
Height: 7 ft 6⅛ in (2·29 m)
Rotor diameter: 28 ft 10½ in (8·8 m)
Weight empty: 838 lb (380 kg)
Weight fully loaded: 1,279 lb (580 kg)
Cruising speed: 75 m.p.h. (120 k.p.h.)
Inclined climb: 689 ft/min (210 m/min)
Absolute ceiling: 9,843 ft (3,000 m)
Range: 171 miles (275 km)
Number of seats: 2

1956 BZ-4

Known familiarly as the 'Zuk', this helicopter was designed by B. Zurakowski, who had also been concerned with the production of the GIL (*q.v.*). An engine of Polish manufacture drives the three-bladed main rotor, which is fitted with an automatic stabilization system, a kind of application of the Hiller principle to a rotor of this type.

The fuselage of welded steel tubes consists of two parts: fore and aft. The forepart, of rectangular section, houses the side-by-side pilots' seats, a bench for passengers, and the engine-transmission unit.

The after part, of triangular section, is a beam housing the shaft driving the two-bladed tail rotor.

The undercarriage has four wheels and there is a strut aft to protect the tail rotor.

This helicopter was given its first public exhibition at the Polish Aviation Day on 26 August 1956.

Engine: WN-4, 320 h.p.
Length: (overall) 42 ft 10 in (13·06 m)
Height: 8 ft 6½ in (2·6 m)
Rotor diameter: 40 ft 4¼ in (12·3 m)
Weight empty: 2,315 lb (1,050 kg)
Weight fully loaded: 3,307 lb (1,500 kg)
Cruising speed: 78 m.p.h. (126 k.p.h.)
max: 85 m.p.h. (137 k.p.h.)
Inclined climb: 905 ft/min (276 m/min)
Range: 158 miles (255 km)
Number of seats: 4

BZ-4

1957 JK-1 TRZMIEL (BUMBLE-BEE)

This single-seater experimental helicopter had a fuselage in welded steel tubes and a two-bladed rotor driven by pulse-jets located at the blade tips, each providing a thrust of 28 pounds (12·5 kilos). The JK-1 was designed by Jerzy Kotlinski and was built under the auspices of the Instytut Lotnictwa.

Engines (2)*:* Pulse-jet Wojcicki
Rotor diameter: 7 ft (2·13 m)
Weight empty: 309 lb (140 kg)

Weight fully loaded: 750 lb (340 kg)
Cruising speed: 65 m.p.h. (105 k.p.h.)
max: 81 m.p.h. (130 k.p.h.)
Inclined climb: 1,969 ft/min (600 m/min)
Service ceiling: 18,045 ft (5,500 m)
Range: 15 minutes' flight.
Number of seats: 1

W.S.K.

In 1956 under the auspices of the Wytwornie Spzetu Konumikacyjnego (Transport Equipment Manufacturing Centre) the Swidnik factories began to build the Russian Mi-1. The original Russian version manufactured in Poland was followed by local modifications, then by a helicopter wholly Polish in design.

1956 SM-1

This is a Polish version of the Soviet Mi-1. Not only the standard model but two others were developed. One is the SM-1S, a medical service helicopter which has a cubicle on each side of the fuselage in which the recumbent patient can be reached by the doctor or nurse through sleeves linking the cubicle to the cockpit. The engine is a 7-cylinder LiT-3, i.e. an A1-26V Soviet engine manufactured in Poland.

The SM-1Z is an agricultural version with spreading, spraying and atomizing devices fitted externally.

At Swidnik in 1957 an SM-1 reached a height of 9,843 feet (3,000 metres) in 6 minutes 45·6 seconds, and achieved an absolute height of 21,000 feet (6,395 metres).

Engine: LiT-3, 575 h.p.
Length: 39 ft $7\frac{5}{8}$ in (12·08 m)
Width: 11 ft $1\frac{7}{8}$ in (3·4 m)
Height: 10 ft $9\frac{7}{8}$ in (3·3 m)
Rotor diameter: 47 ft 1 in (14·35 m)
Weight empty: 4,037 lb (1,831 kg)
Weight fully loaded: 6,429 lb (2,916 kg)
Cruising speed: 115 m.p.h. (185 k.p.h.)
Inclined climb: 787 ft/min (240 m/min)
Ceiling: 9,843 ft (3,000 m)
Range: 342 miles (550 km)
Number of seats: 4

SM-1S

1959 SM-2

This has been designed as a utility modification of the SM-1. Certain structural modifications and a new, redesigned front fuselage make it possible to carry five people. The cabin has two sliding doors. The three-bladed rotor is equipped with de-icing devices.

The first flight took place in 1959.

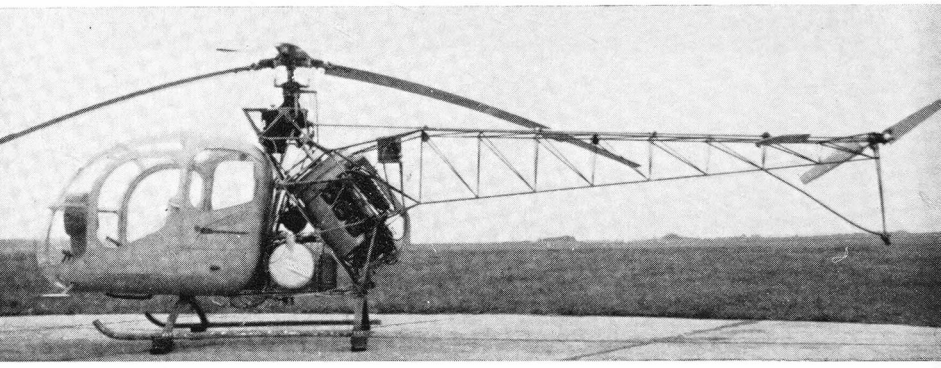
Engine: LiT-3, 575 h.p.
Length: (fuselage) 39 ft $7\frac{5}{8}$ in (12·08 m)
Height: 10 ft $9\frac{7}{8}$ in (3·3 m)
Rotor diameter: 47 ft 1 in (14·35 m)
Weight empty: 2,635 lb (1,195 kg)
Weight fully loaded: 5,589 lb (2,535 kg)
Cruising speed: 81 m.p.h. (130 k.p.h.)
max: 105 m.p.h. (170 k.p.h.)
Inclined climb: 886 ft/min (270 m/min)
Service ceiling: 9,843 ft (3,000 m)
Range: 186 miles (300 km)
Number of seats: 5

1964 SM-4

This utility helicopter of Polish design has a three-bladed rotor and a cabin providing very wide visibility. The cabin is of semi-monocoque design and the tail takes the form of an uncovered metal lattice-work. Behind the cabin is the 6-cylinder engine set at an angle and cooled by a fan on the engine shaft. The landing gear consists of two skids.

Engine: WN-6S, 180 h.p.
Length: (fuselage) 27 ft $10\frac{1}{2}$ in (8·5 m)
Height: 9 ft (2·74 m)
Rotor diameter: 32 ft 10 in (10 m)
Weight empty: 1,455 lb (660 kg)
Weight fully loaded: 2,205 lb (1,000 kg)

Cruising speed: 71 m.p.h. (115 k.p.h.)
max: 84 m.p.h. (135 k.p.h.)
Inclined climb: 919 ft/min (280 m/min)
Service ceiling: 10,827 ft (3,300 m)
Range: 186 miles (300 km)
Number of seats: 3



SM-4

1966 MI-2

Polish production of the Soviet Mi-2 helicopter has resulted in various versions for passenger transport, agriculture, and an ambulance version. This rotorcraft, exhibited for the first time at the Poznan Fair in June 1966, is equipped with two turbines based on a Soviet licence for the GTD-350 and developing 400 h.p. each.

South Africa

In the past few years two developments have been taking place in South Africa, one in the field of autogyros, the other in that of light helicopters.

HELICOPTER MANUFACTURING COMPANY

Some time before 1960, Marquard Vos, formerly a refrigeration engineer, began to take a keen interest in rotary wings and actually built a light single-seater autogyro which was shown at a local exhibition near Cape Town. This was succeeded by a Bensen-type autogyro, then Vos turned his attention towards a helicopter with a two-bladed rotor and a conventional design using a belt-driven anti-torque tail rotor. It was this prototype which was the basis for the Springbok.

1964 SPRINGBOK I

This light helicopter built of tubular steel with a light-alloy sheet and perspex cabin is made up of three primary sub-assemblies: cabin section, centre section with engine, and tail. This arrangement considerably facilitates dismantling for transport by road or air and it also facilitates maintenance.

The two-bladed rotor is of the semi-rigid type with built-in coning. One of the Springbok's special features is the undercarriage, the skids of which are located by two transverse members free to pivot about central points below the engine mounting assembly.

Engine: Lycoming O-320A, 150 h.p.
Length: 27 ft (8·23 m)
Width: 5 ft 4 in (1·63 m)
Height: 9 ft 9 in (2·97 m)
Rotor diameter: 30 ft (9·14 m)
Weight empty: 1,200 lb (544 kg)
Weight fully loaded: 1,850 lb (839 kg)
Cruising speed: 75 m.p.h. (121 k.p.h.)
Range: 130 miles (209 km)
Number of seats: 2

ROTORCRAFT S.A.

The Rotorcraft Company was registered in 1963 to complete the development and possibly undertake mass production of a light autogyro started in 1962 by L. Strydom from a Bensen Gyro-Copter.

1962 MINICOPTER MARK 1

This autogyro has an aluminium-tube structure and a rudder made of light alloy. The engine drives a two-bladed pusher propeller. The two-bladed rotor is of the oscillating-hub type with blades made from steel and wood covered with layers of plastic. The cabin is made of glass fibre and perspex.

The Minicopter was put through a complete testing programme carried out at Worcester, South Africa by the Council for Scientific and Industrial Research. A two-seater version has been projected.

Engine: McCulloch, 72 h.p.
Length: (fuselage) 9 ft 10 in (3 m)
Height: 6 ft 10½ in (2·1 m)
Rotor diameter: 21 ft (6·4 m)
Weight empty: 298 lb (135 kg)
Weight fully loaded: 529 lb (240 kg)
Cruising speed: 68 m.p.h. (109 k.p.h.)
min: 16 m.p.h. (26 k.p.h.)
Number of seats: 1

Spain

Two very important contributions have been made by Spain to rotary-wing developments: Pescara's co-axial rotor helicopter and La Cierva's invention of the autogiro (*q.v.*).

AEROTECNICA

This limited-liability company was until recently a user rather than a producer of aircraft, since its major activities were aerial photography and especially crop spraying from the air.

It extended its interests to construction in 1953 when it engaged the French designer Cantinieau to come to Spain and continue his helicopter research work there. Cantinieau went to Spain with his patents and all his equipment.

This company entirely ceased helicopter construction as from 1962.

1954 AC-11

The main features of this model reproduced those in the MC-101 (see Matra-Cantinieau under France), *viz.*:

Universally-mounted rotor hub.

Upward concentration of weight to increase stability and reduce mechanical linkages.

Very narrow blade profile to increase rotor's performance.

Reduction in flight-control flap because the universal hub prevented transmission of blade flap.

One change in the Spanish version was the substitution of a more powerful Lycoming engine in place of the Hirth: of its total power, about 75 per cent was taken up by the main rotor, and the remainder by the anti-torque rotor, the reduction gear and the two cooling fans.

The fuselage consisted of a lattice filled in with Duralumin tubes to provide rigidity in the aft fuselage and to act as a basis for the cabin and the landing gear.

Engine: Lycoming, 135 h.p.
Length: 21 ft $11\frac{3}{4}$ in (6·7 m)
Width: 5 ft $10\frac{7}{8}$ in (1·8 m)
Rotor diameter: 27 ft $10\frac{5}{8}$ in (8·5 m)
Weight empty: 1,179 lb (535 kg)
Weight fully loaded: 1,687 lb (765 kg)

Cruising speed: 50 m.p.h. (80 k.p.h.)
Inclined climb: 356 ft/min (108·6 m/min)
Absolute ceiling: 8,202 ft (2,500 m)
Range: 2 hours (endurance)
Number of seats: 2

1954 AC-12

This version, derived from the former, was distinguished by a long beam of Duralumin construction on the forepart of which the engine was placed flat beneath the head of the (unchanged) rotor.

Beneath the engine was placed a cabin made of light-alloy and perspex panels, as well as the fuel tank. The landing gear consisted of two standard skids.

Engine: Lycoming O-320, 150 h.p.
Length: 24 ft 9¼ in (7·55 m)
Height: 7 ft 10½ in (2·4 m)
Rotor diameter: 27 ft 10½ in (8·5 m)
Weight empty: 1,058 lb (480 kg)
Weight fully loaded: 1,587 lb (720 kg)
Cruising speed: 71 m.p.h. (115 k.p.h.)
max: 87 m.p.h. (140 k.p.h.)
Inclined climb: 14 ft/sec (4·3 m/sec)
Ceiling: 13,123 ft (4,000 m)
Range: 214 miles (345 km)
Number of seats: 2

1955 AC-13

This model introduced some radical changes: a gas-turbine as power source, and the absence of the anti-torque rotor. The latter was replaced by a gas-ejection outlet issuing from the end of a long tube which constitutes this version's aft structure. At the end of this tube was a muff, the position of which could be varied to direct the jet of gas from either of two sides on to special deflectors. The muff was controlled directly by the steering pedals. The undercarriage was of the same type as in the preceding models: two skis made of large-diameter Duralumin tubes.

Two prototypes of the AC-13 designed by Cantinieau for Aerotecnica were built in France at the SNCAN workshops. One of them was known in France under the designation of N-1750 (Norelfe), and was tested at Melun.

In 1955 the other was tested by the Spanish Air Ministry's Instituto Nacional de Tecnica Aeronautica.

Engine: Turboméca Artouste I, 260 s.h.p.
Length: 24 ft 7¼ in (7·5 m)
Height: 8 ft 10¼ in (2·7 m)

Rotor diameter: 29 ft $7\frac{7}{8}$ in (9·04 m)
Weight empty: 1,268 lb (575 kg)
Weight fully loaded: 1,962 lb (890 kg)
Cruising speed: 77 m.p.h. (124 k.p.h.)
max: 87 m.p.h. (140 k.p.h.)
Inclined climb: 1,181 ft/min (360 m/min)
Absolute ceiling: 19,685 ft (6,000 m)
Range: 1 hour (endurance)
Number of seats: 3

1956 AC-14

The building of this version, which is a development of the AC-13, was started in 1956. The AC-14 has a four-bladed rotor.

Engine: Turboméca Artouste II, 360 s.h.p.
Length: 26 ft $8\frac{1}{8}$ in (8·13 m)
Height: 9 ft $0\frac{1}{4}$ in (2·75 m)
Rotor diameter: 31 ft $7\frac{7}{8}$ in (9·65 m)
Weight empty: 1,367 lb (620 kg)
Weight fully loaded: 2,646 lb (1,200 kg)
Cruising speed: 93 m.p.h. (150 k.p.h.)
max: 106 m.p.h. (170 k.p.h.)
Inclined climb: 984 ft/min (300 m/min)
Range: 280 miles (450 km)
Number of seats: 5

AC-14

1957 AC-21 (PROJECT)

To meet the requirements of the Spanish Air Force Staff and possible military, naval and civil users, Aerotecnica developed a helicopter with

four blades powered by two linked gas-turbines. It was in some ways an extrapolation of the earlier AC-13 and AC-14 and it used the same deflection method for countering torque, situated, as before, in the tail. Sufficient power was provided to enable the AC-21 to fly, if necessary, with just one of its two turbines.

Length: (fuselage) 45 ft $11\frac{1}{8}$ in (14 m)
Height: 13 ft $6\frac{1}{4}$ in (4·12 m)
Rotor diameter: 55 ft $9\frac{1}{4}$ in (17 m)
Weight empty: 4,409 lb (2,000 kg)
Weight fully loaded: 8,818 lb (4,000 kg)
Cruising speed: 124 m.p.h. (200 k.p.h.)
max: 143 m.p.h. (230 k.p.h.)
Inclined climb: 1,772 ft/min (540 m/min)
Absolute ceiling: 30,840 ft (9,400 m)
Range: $6\frac{1}{2}$ hours (endurance)
Number of seats: 12

AISA

AISA, the abbreviated name of Aeronautica Industrial S.A., has been an aircraft manufacturer since 1923 and has concentrated mainly on output in wooden or mixed construction.

After producing Savoia Marchettis under licence, the company turned to the production of various trainers and also of a glider, all designed by the Instituto Nacional de Tecnica Aeronautica.

Among relatively recent models mention may be made of the light aircraft HM-1 and HM-1B, various biplane trainers and the I-115 military trainers.

AISA also took over the Aircraft Department of Iberia S.A., the Spanish airline.

1953 IH-52 (PROJECT)

The helicopter was of conventional design and it was planned to use a Spanish-built engine as power source. It was to have one three-bladed main rotor and one two-bladed anti-torque tail rotor.

1954 IH-51 (PROJECT)

Developmental work was done on this ultra-light helicopter, in which pulse-jet engines were to be fitted at the tips of a single two-bladed rotor.

LA CIERVA

During the developmental period of the 1920s, one of the most outstand-

ing achievements was the invention by Juan de la Cierva of the autogiro, a machine intermediate between the conventional aircraft and the true helicopter.

The form is a hybrid in that the aircraft is pulled or pushed through the air by a conventional airscrew, but lift during flight is provided by rotary wings revolving in auto-rotation through the action of the air, whereas a true helicopter's rotor is power-driven.

La Cierva's interest in rotary wings was aroused by an accident. On finishing his engineering studies in Madrid, he built the first Spanish three-engined biplane in 1918. The following year this aircraft crashed as the result of stalling. La Cierva, then twenty-four, determined to find a solution to that problem. The ensuing work was to occupy him until the fatal air accident in which he lost his life at Croydon aerodrome on 9 December 1936. He discovered that rotary wings revolving freely maintained sufficient lift for an aircraft, irrespective of the latter's speed. Not only could stalling be avoided in this way, but also the torque which would occur if the wings were rotated by an engine.

Various unsuccessful models, respectively known as C-1, C-2 and C-3, were followed by the C-4, with which in January 1923 La Cierva made his first autogyro flight. It was the first of a long family of autogyros.

In 1925 La Cierva went to the United Kingdom, where soon afterwards a firm known as the Cierva Autogiro Company Ltd was set up to manage his various patents and also the manufacturing rights. Among licence-holders from La Cierva were A. V. Roe, Parnall, Weir, Westland, De Havilland, Comper and Airwork in Britain, Lioré and Olivier in France, and Focke-Wulf in Germany. In 1929 the American rights were acquired by the Pitcairn organization which founded the Autogiro Company of America. The latter granted licences to Pitcairn himself, and to Kellett and Buhl.

La Cierva worked tirelessly to improve his invention. The improvements achieved in starting ranged from taxiing to rope starting, starting by deflected slipstream, and finally mechanical-drive starting. As regards control, the 'fixed head' was followed by direct control, and then by the 'auto-dynamic' head which enabled the autogyro to take off and land without any ground run, and which shortly predated the inventor's death.

1920 C-1

For this prototype which he built at Madrid, La Cierva used the fuselage of a Deperdussin, a French monoplane of pre-World War I vintage, on which were mounted two contra-rotating four-bladed rotors. The C-1 had a vertical surface above the rotor to give lateral control. This model never flew, since it proved impossible to control: the lift from the two rotors was unbalanced because of mutual interference.

Engine: Le Rhône, 60 h.p.

Rotor diameter: 20 ft (6·1 m)
Weight fully loaded: 772 lb (350 kg)
Number of seats: 1

1921 C-2

This prototype was completed early in 1921. Above the centre of gravity of a Hanriot fuselage retaining its customary elevators and rudder was fitted a three-bladed rotor, the blades of which incorporated variation of the angle of incidence.

Of this aircraft, La Cierva himself spoke as follows: 'My first experiments with this type were encouraging. But after this model had been damaged and reconstructed nine times, it seemed clear that the solution would not be found in such a design.' Gyroscopic effects in fact proved virtually insurmountable.

1922 C-3

At the beginning of 1922 this prototype with five rigid blades was ready for trial. Though its lateral control was improved, it always showed in the inventor's own words 'a tendency to fall over sideways'. It was damaged on several occasions and rebuilt four times.

An end was put to La Cierva's failures by a toy autogyro which he had built. Its engine consisted of a twisted rubber band, and its rotary wings of flexible palm-wood. Unlike the full-sized machines, it flew properly. On comparing it feature by feature with the C-3, La Cierva discovered that the flexible rotor blades accounted for the toy's successful flight. This gave La Cierva the idea of articulating the blades so as to overcome the imbalance between the advancing and retreating blades.

1922 C-4

The four blades of this prototype were articulated at the root and were thus able to flap vertically. The original model did not fly, but after various trials and modifications, such as the addition of ailerons on outriggers, the C-4 flew for the first time on 9 January 1923 at Getafé aerodrome on the outskirts of Madrid and covered 200 yards (183 metres). The autogyro was moved to Cuatro Ventros aerodrome, also in the Madrid neighbourhood, and at the end of the same month performed a closed circuit flight of 2½ miles (4 kilometres) in 4 minutes at a height of about 100 feet (30·5 metres). Hinged, articulated blades thus proved the answer to the difficulties encountered in the previous types.

Engine: Le Rhône 9 JA, 110 h.p.
Rotor diameter: 32 ft (9·75 m)
Number of seats: 1

1923 C-5

Similar to the C-3 and also equipped with a Le Rhône 9 JA 110 h.p.

engine, this autogyro with a three-bladed rotor first flew at Getafé in July 1923.

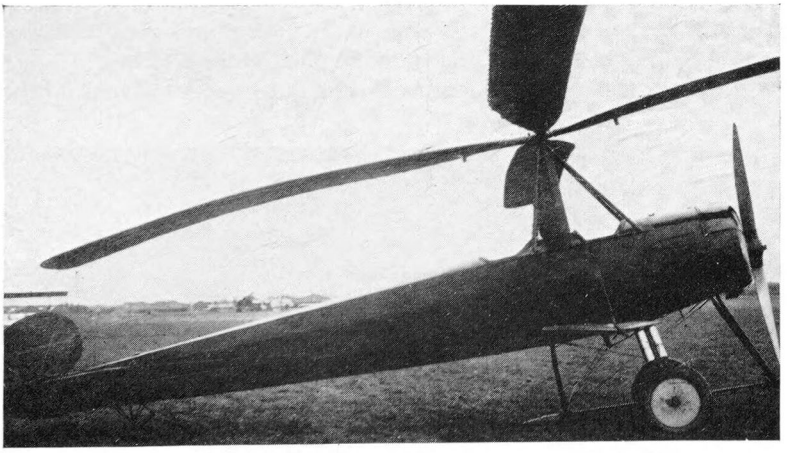
1924 C-6

This prototype, unlike its predecessors financed from private sources, was built with the help of subsidies from the Spanish Government and made its maiden flight in May 1924. It had an Avro 504K fuselage with ailerons on outrigger spars, a Le Rhône 9 JA 110 h.p. rotary engine and a four-bladed rotor with flapping hinges 36 feet (10·97 metres) in diameter and turning at 140 r.p.m.

To shorten the autogyro's take-off run, the rotor was spun-up to 60 r.p.m. by means of a rope.

On 12 December 1924 the first successful cross-country flight was made over the $7\frac{1}{2}$ miles (12 kilometres) between the airports of Cuatro Ventros and Getafé.

In October 1925 the C-6A was brought to England and performed a series of demonstrations at the Royal Aircraft Establishment, Farnborough. These were so convincing that the Air Ministry decided to order several autogyros to be tried out by the Royal Air Force. This gave rise to the Cierva Autogiro Company Ltd, which managed the rights in La Cierva's inventions. The firm of A. V. Roe was selected to build the British version, the C-6C.



C-6

LORING

Jorge Loring built an autogyro of the La Cierva type which was exhibited at the 1926 Madrid Air Show.

His company also built various rotorcraft conceived in Spain and designed by Barron, such as the Loring R-1, R-2, R-3, etc. The company also held a manufacturing licence for Spain from the Fokker group.

1926 C-7

This two-seater autogyro, produced by Loring, had a four-bladed rotor mounted on a Loring-type fuselage, and was given its first tests at Cuatro Ventros in 1926. Two such autogyros were built.

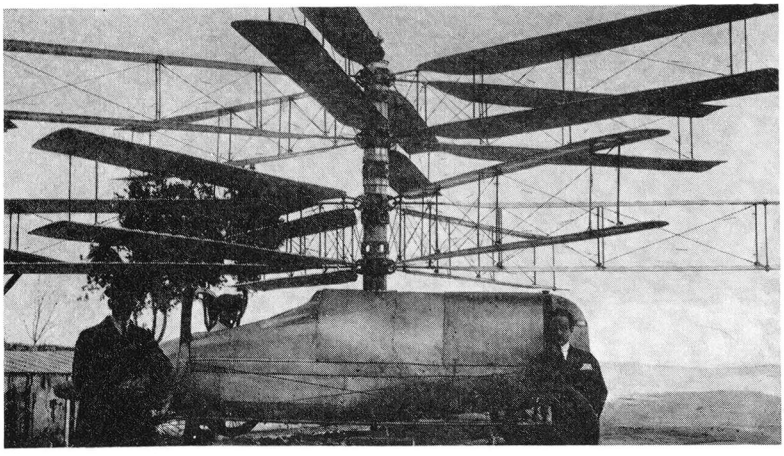
Engine: Hispano-Suiza, 300 h.p.
Rotor diameter: 39 ft $6\frac{3}{4}$ in (12·06 m)
Number of seats: 2

PESCARA

Between 1919 and 1920 a Spanish marquis, Pateras Pescara, constructed in Barcelona an aircraft with 24 lifting surfaces, i.e. two six-bladed 'biplane' co-axial rotors 21 feet (6·4 metres) in diameter. The 45 h.p. of the Hispano engine he used proved inadequate to lift this cumbersome arrangement.

In the middle of May 1921, when powered by a 170 h.p. Le Rhône rotary engine, the helicopter did succeed in rising slightly off the ground. This machine possessed in rudimentary form the control equipment found in modern helicopters: a stick and a switch providing collective control by simultaneously working on the pitch of the blades.

In 1922 Pescara came to France and carried out a series of tests for the



PESCARA

Service Technique de l'Aéronautique (Aeronautical Technical Service), during which he reached a height of 5 feet (1·5 metres) from the ground, but his stability was always hazardous.

After introducing various design modifications to later models, such as more powerful engines and fewer lifting surfaces, and after carrying out further tests, Pescara on 18 April 1924, at Issy-les-Moulineaux on the outskirts of Paris, made a flight of slightly under 805 yards, and thus beat by just over 218 yards the previous record set up only one day earlier by the French pioneer, Oemichen (*q.v.*).

In 1925 Pescara built his third model, the 3F, with two four-bladed rotors driven by a 250 h.p. engine, but no better results were obtained.

Shortly afterwards Pescara returned to Spain and went in for motor-vehicle production. At a later date, with the help of a Frenchman named Pouit, he built his S-4, a type of small convertible, again with co-axial rotors, weighing 882 pounds (400 kilos) and powered by a 40 h.p. Salmson engine, with an airscrew that could be geared as desired. This machine was unquestionably more stable than its predecessors, but by then La Cierva had his autogyro successfully flying and was beginning to make a name for himself outside Spain.

Switzerland

BERGER

During 1961–2 Hans Berger, who runs an aeronautical equipment agency at Zürich, produced a small single-seater helicopter. Its success has encouraged him to work on a second of larger size.

1963 BERGER BX-50

This small, highly simplified single-seater has a three-bladed rotor. The chassis consists of steel tubes and the transmission makes use of belts and pulleys. The first flights took place in 1962.

Engine: Continental, 85 h.p.
Length: 17 ft 6½ in (5·35 m)
Height: 7 ft 5¾ in (2·28 m)
Rotor diameter: 21 ft 4 in (6·5 m)
Weight empty: 569 lb (258 kg)
Cruising speed: 75 m.p.h. (120 k.p.h.)
Inclined climb: 787 ft/min (240 m/min)
Range: 224 miles (360 km)
Number of seats: 1

1964 BK-300 (PROJECT)

This project is for a larger machine equipped with a turbine, a 300 h.p. Oredon III, to drive a three-bladed rotor of 30 feet 3 inches (9·2 metres) diameter. The machine has been designed with a small stub wing.

DUFAUX, 1905

The Dufaux brothers of Geneva, inventors of the 'moto-sacoche', in 1905 built a helicopter with a total weight of 37 pounds (17 kilos) and with rotors driven by a 2-cylinder 3 h.p. engine. The actual rotors were two-bladed, and a pair of them, turning in opposite directions, were mounted at either end of lateral outriggers.

During its test at the Saint Cloud aerodrome the aircraft successfully lifted not only its own weight but also a load consisting of 14 pounds (6½ kilos) of ballast. During these lifting experiments, the aircraft was guided by vertical cables, since no way had been found to ensure either lateral movement or stability.

Following these trials, the Dufaux brothers in 1908 produced a larger version with a Dufaux 100 h.p. engine mounted on a fixed-wing aircraft body and helicopter mechanism. This model was designed to take off and land vertically and to glide horizontally by means of the aircraft wings which it possessed.

STIERLIN

In Geneva two amateurs named Stierlin and Mercier, one a mechanic, the other a locksmith, have carried out very thorough tests on small-scale helicopters. The tests have included ground trials, flight in auto-rotation, etc., but have mainly been concerned with a gyroscopic stabilizer system.

1954 STIERLIN

In 1954 a successful flight was made by the third version of the rotorcraft built by Stierlin and Mercier.

The first version was powered by a single-cylinder Villiers engine of insufficient power to lift the helicopter. The second engineless version enabled the constructors to study the rotor's behaviour in auto-rotation when the aircraft was towed behind a motor-car.

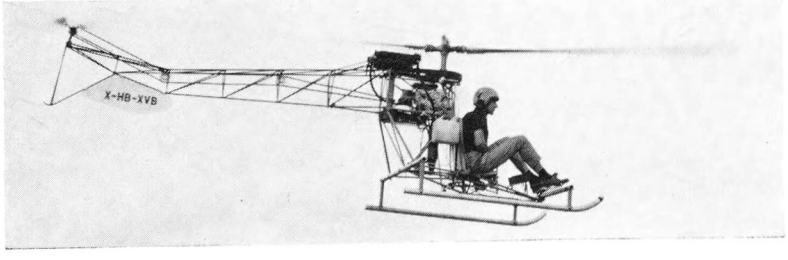
The third model was exhibited at a competition for light helicopters at St Etienne in France in 1954.

The rotor has two blades and a gyroscopic stabilization system. The framework is very rough and consists of welded uncovered tubes. There is a tricycle undercarriage with a wheel forward.

Engine: Salmson, 40 h.p.
Rotor diameter: 21 ft 6 in (6·55 m)
Number of seats: 1

1964 STIERLIN

The model designed in 1954 was followed by another in 1960 with a 65 h.p. Continental engine and in 1964 by a third with different mechani-



STIERLIN 1964

cal features. It has an outboard engine cooled by a motor-car radiator, mounted vertically and, through pulleys, driving both the main two-bladed and the tail rotors. The fuselage is made of tubes, the landing gear of two tubular skids.

The first flights took place in November 1964.

Engine: Johnson, 40 h.p.
Rotor diameter: 18 ft $4\frac{1}{2}$ in (5·6 m)
Weight empty: 273 lb (124 kg)
Cruising speed: 62 m.p.h. (100 k.p.h.)
Range: 20 minutes' flying time
Number of seats: 1

United States of America

While the earliest attempts with rotary wings in the United States go back to de Bothezat soon after World War I, subsequent tangible results are mainly connected with the name of Sikorsky as from 1939. Eventually various American firms turned their attention to the problems connected with helicopters, and this work made the United States the leader in the field following World War II. Today, rotorcraft by such American firms as Bell, Hiller, Vertol and Sikorsky are flying in all parts of the world.

ADAMS-WILSON

In Lakewood, California, T. Adams and P. Wilson have set up a company to market the plans and do-it-yourself kit for an experimental conventional-type helicopter.

1958 101 HOBBYCOPTER

This home-made helicopter has a two-bladed spruce rotor driven by a motor-cycle engine. Cyclic and collective pitch are controlled by a swash plate. The fuselage is made of bolted aluminium tubes.

The prototype first flew in November 1958.

Engine: Triumph, 40 h.p.
Length: 14 ft (4·27 m)
Width: 5 ft (1·52 m)
Height: 6 ft (1·83 m)
Rotor diameter: 21 ft 6 in (6·55 m)
Weight empty: 355 lb (161 kg)
Weight fully loaded: 555 lb (252 kg)
Cruising speed: 40 m.p.h. (64 k.p.h.)
Ceiling: 8,000 ft (2,438 m)
Range: 55 miles (89 km)
Number of seats: 1

AERONAUTICAL PRODUCTS

Aeronautical Products Inc., which manufactures aircraft engine parts,

continued work on a helicopter design begun, before they left the firm, by Corwin Denney and Karl Schakel.

The aircraft was damaged during preparations for the first trial flights, but it was rebuilt and eventually flew successfully. It was not, however, actually put into production.

In 1947 Aeronautical Products merged with the McQuay Company.

1944 MODEL 3

This helicopter's fuselage, of fabric-covered welded steel tubing, resembled that of a light aircraft with the engine located in the forward section and placed horizontally forward of the cabin instead of being situated centrally, as in most helicopters.

Power from the engine, cooled by a fan mounted directly above it, was transmitted by pulleys and vee belts to a horizontal main driveshaft, then through a bevel gear drive to the main rotor shaft which passed between the pilot's and the passenger's seats.

Mounted on the vertical rotor driveshaft was the main gearbox for the tail shaft operating the two-bladed anti-torque rotor, with a diameter of 5 feet 8 inches (1·73 metres), the pitch of which was controlled by rudder pedals. This rotor's maximum rotational speed was 1,200 r.p.m.

The three blades of the main rotor were made with tapered tubular spars and also connected to the root spars by a double-action hydraulic shock-absorber.

Cyclic pitch control was obtained by a hanging stick while on the engine throttle support was the collective pitch control.

Engine: Franklin 6AC-298, 165 h.p.
Rotor diameter: 30 ft (9·14 m)
Weight fully loaded: 1,200 lb (544 kg)
Number of seats: 2

ALTOCSAN

In 1953 Charles Miller, formerly a designer with Kellett and with the Piasecki Helicopter Company and at the time vice-president of the Altocsan Company, a small firm affiliated with the Quaker City Metal Weatherstrip and Technical Manufacturing Company, started to build a small model pilotless helicopter electrically powered and tethered to the ground.

1954 ALTOCSAN

This pilotless helicopter has two contra-rotating co-axial two-bladed rotors powered by a three-phase electric motor located under the rotor group. The height it can reach is limited by the length of the power and

tethering cables. It can be fitted to act as an antenna tower for low-frequency wireless transmission, and also as a submarine detector by the installation of sonar or similar equipment.

Engine: 12 h.p. electric motor
Rotor diameter: 14 ft (4·27 m)
Weight empty: 140 lb (64 kg)
Weight fully loaded: 270 lb (122 kg)

AMERICAN HELICOPTER COMPANY

The American Helicopter Company was formed by C. D. Denney in 1947 with the object of applying pulse-jet engines to helicopters. Three types of rotorcraft were in turn built for military purposes: the Top Sergeant, Buck Private and Jet Jeep. Then in April 1954 the company was taken over by the Fairchild Engine and Airplane Corporation, in which it became known as the American Helicopter Company Division of the parent organization.

1949 XA-5 TOP SERGEANT

The Top Sergeant used the front section of a Sikorsky R-6 fuselage and was powered by two pulse-jet engines, each with a static thrust of 95 pounds (43 kilos) and manufactured by the American Helicopter Company.

These engines could be set in motion by injecting air from a hose or by means of a compressed-air container forming part of the helicopter.

Both the cyclic pitch and collective control system were of the swash-plate type. The Top Sergeant flew for the first time in January 1949.

Engines (2)*:* AJ 8·75 in, 95 lb (43 kg) pulse-jet
Length: 22 ft 2 in (6·76 m)
Rotor diameter: 36 ft (10·97 m)
Weight empty: 960 lb (435 kg)
Weight fully loaded: 1,800 lb (816 kg)
Cruising speed: 55 m.p.h. (89 k.p.h.)
max: 75 m.p.h. (121 k.p.h.)
Absolute ceiling: 14,000 ft (4,267 m)
Range: 140 miles (225 km)
Number of seats: 2

1951 XA-6 BUCK PRIVATE

This model, which was developed under the sponsorship of the United States Air Force, was made up of a tubular aluminium chassis with, at its base, a tricycle undercarriage, and at the upper end the rotor; immediately

XA-5

behind the pilot's seat was a vertical rudder mounted on the end of the tubing.

The two-bladed rotor was fitted at each tip with a pulse-jet developing a 35-pound (16-kilo) static thrust. These pulse-jet engines had an overhaul life of fifty hours. At the end of this period, the only moving part, the valve assembly, required replacement.

The Buck Private flew for the first time in February 1951.

Engines (2)*:* AJ 6·7 in, 35 lb (16 kg) pulse-jet
Length: 13 ft 6 in (4·11 m)
Rotor diameter: 27 ft (8·23 m)
Weight empty: 200 lb (91 kg)
Weight fully loaded: 720 lb (327 kg)
Cruising speed: 60 m.p.h. (97 k.p.h.)
Range: 125 miles (201 km)
Number of seats: 1

1952 XH-26 JET JEEP

The development of this helicopter was supervised by the United States Army and Air Force.

The single-seater is less rudimentary than its two forerunners, but even so it can be very rapidly collapsed and packed into a container measuring 5 feet by 5 feet by 14 feet (1·52 by 1·52 by 4·27 metres). The container can be air-dropped and the helicopter be put back into flying order in less than thirty minutes.

The Jet Jeep is powered by two 35-pound pulse-jet engines manufactured by the American Helicopter Company. The prototype made its maiden flight in June 1952.

Engines (2): AJ 7·5 in, 35 lb (16 kg) pulse-jet
Height: 6 ft (1·83 m)
Rotor diameter: 27 ft (8·23 m)
Weight empty: 300 lb (136 kg)
Weight fully loaded: 875 lb (397 kg)
Cruising speed: 70 m.p.h. (113 k.p.h.)
max: 80 m.p.h. (129 k.p.h.)
Range: 105 miles (169 km)
Number of seats: 1

XH-26

AUTOGIRO COMPANY OF AMERICA

In 1925 H. F. Pitcairn, accompanied by an engineer named Agnew E. Larsen, visited Spain to inspect the work being done by La Cierva.

In 1928 Pitcairn visited the United Kingdom, where he acquired the U.S.A. manufacturing rights from the Cierva Autogiro Company and also brought back a version known as C-8 Mark IV or C-8W, which had been built by the British firm, A. V. Roe (*q.v.*).

The Autogiro Company of America was founded in 1929 to exploit the manufacturing rights which Pitcairn had acquired.

Various U.S.A. firms benefited from these rights. Among them were

the Pitcairn Autogiro Company, the parent company of the Autogiro Company of America; Kellett Aircraft Corporation; and the Buhl Company, which produced a single aircraft of the pusher type (see under each).

BANNICK

Lester Bannick has built a prototype autogyro with a design resembling the Bensen and intended to be sold in the form of kits.

1964 MODEL T

This light autogyro, with a two-bladed rotor of spruce covered with fibreglass, can take off at a speed of 26 m.p.h. (42 k.p.h.) and land at 8 m.p.h. (13 k.p.h.).

Engine: 65 h.p.
Rotor diameter: 25 ft (7·62 m)
Weight empty: 350 lb (159 kg)
Weight fully loaded: 800 lb (363 kg)
Cruising speed: 60 m.p.h. (97 k.p.h.)
Number of seats: 1

BELL

Lawrence D. Bell first entered into the aircraft industry in 1912, the year when he began work as an aircraft mechanic. He later filled executive positions with the Glenn L. Martin Company and the Consolidated Aircraft Company.

In 1935 he founded his own organization, the Bell Aircraft Corporation, since when the policy of diversification has been continuously extended. Besides such straightforward aircraft as the Airacuda, Airacobra, Kingcobra and in 1942 the first American jet-propelled aircraft, the Airacomet, the Bell organization has produced special rocket-powered research aircraft such as the supersonic X-1, X-2 and X-5 (the latter with variable sweep-back wings), and an experimental convertible with turbines inclined vertically downwards for take-off and able to swing up on trunnions to provide the horizontal thrust essential to forward flight. It has also made rocket engines such as those used in the Nike surface-to-air missiles, servo devices, high-precision electronic equipment, etc.

In 1942 Bell turned its attention to the work being done in the rotary-wing field by Arthur Young and by Kelley. Young, in particular, had designed a rotor which, when finalized, was to become standard in all the Bell Helicopter Division's output.

Young's rotor had a special feature: a stabilizing hub, which works on the following principle. If a gust of wind tilts the helicopter, balance is

lost because the rotor, linked to the fuselage by a mast, is also tilted. Were balance to be maintained, the pitch of the blades would need to be made independent of the mast position. This can be done by controlling pitch through a stabilizing bar at right-angles to the blades which remains constantly in the same plane of rotation no matter how much the mast may deviate. Consequently with a two-bladed see-saw-type rotor, cyclic pitch control plus the gyroscope effect of the stabilizing bar automatically provide good stability.

Apart from helicopters with a single main rotor and one model with two rotors and the stabilizing hub, Bell has also worked on a convertiplane with pivoting rotors, compound helicopters, projects such as 'trailing rotor' aircraft and various far-sighted research programmes.

In 1957, the year following L. Bell's death, a wholly-owned subsidiary, the Bell Helicopter Corporation, was formed in Texas. In 1960 the Bell Helicopter Company of Fort Worth became one of three separate and autonomous divisions (of which the other two were the Bell Aerosystems Company and the Hydraulic Research and Manufacturing Company) of a new corporation, the Bell Aerospace Corporation, a wholly-owned subsidiary of Textron Inc. of Providence, Rhode Island.

The following list records rotorcraft produced by Bell on a large or medium scale and the year in which the first deliveries were made.

Model 47 of which more than 3,000 were built between 1946 and 1964 and the production of certain types of which still continues:

Year	*Bell Designation*	*Military Designation*
1946	47B	
1947	47B-3	
	47A	HTL-1 (Navy)
		YH-13 (Air Force)
1948	47D	HTL-2 (Navy)
		H-13B (Army)
1950	47D-1	HTL-3 (Navy)
		HTL-4 (Navy)
		HTL-5 (Navy)
		H-13D (Army)
	47G	HTL-6 (Navy)
		H-13G (Army)
1955	47G-1	
	47G-2	H-13H (Army)
	47H	
	47J	HUL-1G (Coast Guard)
		HUL (Navy)
		H-13J (Air Force)

Year	*Bell Designation*	*Military Designation*
1958	47K	HTL-7 (Navy)
1960	47G-3	H-13K (Army)
	47J-2	
1961	47G-3B	OH-13S (Army)
1962	47G-2A	
	47G-2A-1	
1963	47G-3B-1	TH-13T
	47G-4	
1964	47J-2A	
	47G-4	
1965	47G-4A	
1966	47G-5	
Other Models		
1954	61	HSL (Navy)
1958	204	XH-40 (Army)
		YH-40 (Army)
		UH-1 (Army)
1959		UH-1A (Army)
1961		UH-1B (Army)
1962	204B	
	205	YUH-1D (Army)
		UH-1D
1963	204	UH-1E (Marine Corps)
		UH-1F (Air Force)
1964	206	OH-4A
1965	204	UH-1C (Army)
1967	209	AH-1G
1969	212	

1943 MODEL 30

This rotocraft, built in late 1942 and early 1943, flew in its simple-structure state as from the spring of the latter year.

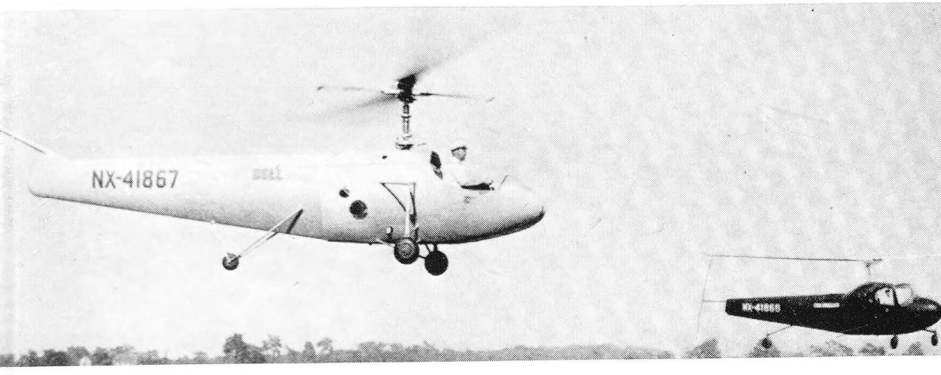
The main rotor had two laminated wood blades, approximately 10 inches (26 centimetres) in width. They were articulated as a complete unit, i.e. each was rigidly mounted in respect of the other. At right-angles to the blades there was a kind of balance with a streamlined counterweight at each end which acted as a stabilizing system.

The landing gear of the first version consisted of four Duralumin tubes 12 feet (3·66 metres) in length, the ends of which were fitted to the fuselage close to the top of the engine and actually attached to the fuselage by a secondary tube fitted with a shock-absorber.

Excessive vibration resulted in damage during the flight tests, but this

vibration was later overcome and several of the trial versions were subsequently built.

Engine: Franklin, 160 h.p.
Rotor diameter: 33 ft (10·06 m)
Number of seats: 2



BELL MODEL 30

1946 MODEL 47

The long series of thorough and exhaustive tests to which the original Model 30 was subjected led directly to the first Model 47, which, following an extensive test programme, was awarded the world's first commercial helicopter licence and certificate by the United States Civil Aeronautics Administration.

The year 1946 saw the production of the first run of ten Model 47s, which were the forerunners of a long series still in production today and incorporating the numerous improvements and refinements suggested by the wealth of operational data which has been accumulated. These helicopters are variously known as 47B, 47B-3, 47D, 47D-1, etc. (see list above). The first versions of the Model 47 were the YH-13 designation of the United States Air Force, the YH-13A, a winterized modification, and the HTL-1, the United States Navy designation. All these rotorcraft were two-seaters equipped with an air-cooled Franklin 178 h.p. engine.

1946 47B

The commercial version had two side-by-side seats with dual control in a cockpit somewhat resembling that of a motor-vehicle.

The air-cooled engine placed vertically aft of the cabin drove the main and the tail rotors through a clutch and a free-wheeling device. The main two-bladed rotor was of the Bell type with a stabilizing bar 8 feet 4 inches

(2·54 metres) in length. The luggage compartment was on the right-hand side between the engine and the tail boom. Attached to the latter, just below the tail rotor, was a tail skid. The main landing gear consisted of four wheels, of which the two front ones were self-castoring.

The 47B-2 crop-sprayer version and the 47B-3 crop-duster version had an open cockpit which gave the pilot far better visibility but which proved very damp under certain atmospheric conditions.

Engine: Franklin 6V4-178-B32, 178 h.p.
Height: 8 ft 6 in (2·59 m)
Rotor diameter: 35 ft 1½ in (10·71 m)
Weight fully loaded: 2,100 lb (953 kg)
Cruising speed: 80 m.p.h. (129 k.p.h.)
Inclined climb: 1,000 ft/min (305 m/min)
Absolute ceiling: 11,400 ft (3,475 m)
Range: 212 miles (341 km)
Number of seats: 2

47A

1947 47D (H-13B, HTL-2, H-13C)

The visibility in this Bell helicopter showed a marked improvement over the 47B, thanks to the transparent, spherical cockpit.

The aft section supporting the tail rotor was still made of a metal trellis.

H-13B was the Army, HTL-2 the Navy designation, while H-13C designated a version identical with the H-13B except for its more powerful (Franklin 200 h.p.) engine.

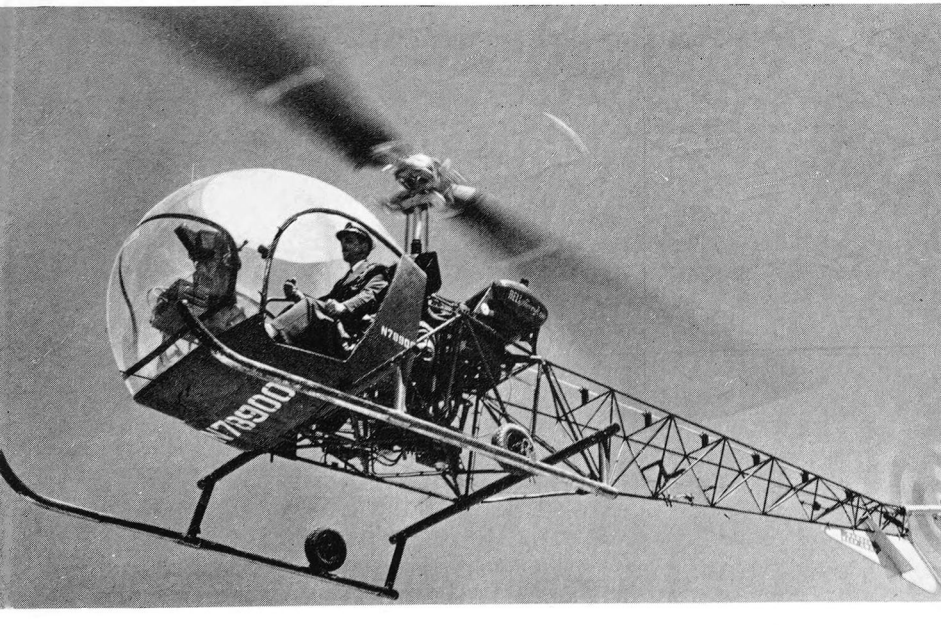
Engine: Franklin 6V4-178-B32, 178 h.p.
Rotor diameter: 35 ft 1½ in (10·71 m)
Weight fully loaded: 2,200 lb (998 kg)
Cruising speed: 85 m.p.h. (137 k.p.h.)
Inclined climb: 11,500 ft (3,505 m)
Number of seats: 2

1947 47D-1 (H-13D, H-13E, HTL-3, 4 AND 5)

This was an improved version of the 47D, in which the main changes were in the seating capacity (three instead of two side-by-side seats) and the cockpit (one-piece bubble canopy instead of the former split type). The engine was more powerful than that of the 47Bs and the first 47Ds, since it developed 200 h.p.

The 47D-1 could also be supplied in an agricultural version for such specialized duties as dusting or spraying crops.

The United States Army and Air Force designated this rotorcraft H-13D, the United States Navy, which used it from 1950 onwards, HTL-3, HTL-4 and HTL-5. The versions designated H-13E and HTL-5



47D-1

are respectively identical with the H-13D and HTL-4 designations, but they possess an improved transmission system.

On 17 September 1952 a Bell 47D-1 set up a record for non-stop distance in a straight line without payload of 1,958·796 kilometres.

1949 47G (H-13G, HTL-6)

This improved Model D was a light, multi-purpose three-seater powered by a Franklin engine which, through a two-stage planetary transmission system, drove a main rotor of laminated wooden blades with steel leading edges, a tail rotor and a cooling fan.

There were three main components: the cabin with a bubble-type Perspex (Plexiglass) canopy, the central component with the engine and transmission system, and the body, a welded tube structure.

This helicopter had a synchronized elevator directly linked to the cyclic pitch control lever, an improvement which gave better stability and an increased margin of centre-of-gravity travel.

The landing gear consisted of two skis 9 feet 5 inches (2·87 metres) apart, and, if needed, quick-change flotation gear could be fitted. In the former case, two small wheels assisted handling on the ground.

This helicopter has been used in more than forty countries for agricultural purposes, aerial survey, police patrol, rescue work and other duties.

The service designations were H-13G in the United States Air Force, and HTL-6 in the United States Navy. 47G-1 is the designation given to a prototype of the 47J equipped with a Lycoming engine derated from 250 h.p.

Engine: Franklin 6V4-200-C32, 200 h.p.

Length: (overall) 41 ft 2½ in (12·56 m)

47G

Rotor diameter: 35 ft 1½ in (10·71 m)
Weight empty: 1,380 lb (626 kg)
Weight fully loaded: 2,350 lb (1,066 kg)
Cruising speed: 77 m.p.h. (124 k.p.h.)
max: 90 m.p.h. (145 k.p.h.)
Inclined climb: 800 ft/min (244 m/min)
Absolute ceiling: 10,900 ft (3,322 m)
Range: 215 miles (346 km)
Number of seats: 3

1955 XH-13F

This prototype consisted of a Bell 47G which, purely for experimental purposes, was fitted with a rotor driven by a 280 h.p. Continental XT51-T-3 (Turboméca Artouste) shaft-turbine. The latter was mounted on the fuselage directly adjacent to the rotor.

1955 47G-2 (OH-13H SIOUX) TROOPER

The former H-13H became the military version OH-13H Sioux. From 1955 to 1961 inclusive it was regularly delivered to the armed forces.

This standard helicopter's most frequent use was armed reconnaissance, evacuation of wounded, command liaison, wire laying and light resupply.

Engine: Lycoming VO-435-A1A, B or D, 200 h.p.

47G-2

Height: 9 ft 5 in (2·87 m)
Rotor diameter: 35 ft 1½ in (10·71 m)
Weight empty: 1,564 lb (709 kg)
Weight fully loaded: 2,450 lb (1,111 kg)
Cruising speed: 89 m.p.h. (143 k.p.h.)
max: 100 m.p.h. (161 k.p.h.)
Inclined climb: 807 ft/min (246 m/min)
Service ceiling: 12,630 ft (3,850 m)
Range: 238 miles (383 km)
Number of seats: 3

1960 47G-2A

This helicopter's engine provides 240 h.p. at take-off and 220 h.p. in continuous operation. The rotor system is identical with that in Model 47J-2 (*q.v.*). The rotating controls from the swash plate to the mixing levers have been completely redesigned in the 47G-2A. The main rotor pitch-change link-bearings have been replaced by spherical-rod end-bearings with Fabroid inserts that require no lubrication.

1962 47G-2A-1

This version has the engine and dynamic components of the 47G-2A but a wider carriage and an increased fuel capacity than in earlier versions.
Engine: Lycoming VO-435-A1E or F, 240 h.p.
Length: 31 ft 6 in (9·6 m)
Width: 8 ft 8 in (2·64 m)
Height: 9 ft 4 in (2·85 m)
Rotor diameter: 37 ft 2 in (11·33 m)
Weight empty: 1,650 lb (748 kg)
Weight fully loaded: 2,850 lb (1,293 kg)
Cruising speed: 90 m.p.h. (145 k.p.h.)
max: 105 m.p.h. (169 k.p.h.)
Inclined climb: 800 ft/min (244 m/min)
Service ceiling: 9,000 ft (2,743 m)
Range: 290 miles (467 km)
Number of seats: 3

1959 47G-3 (OH-13K)

This helicopter, resembling the 47G-2 but with a 225 h.p. turbocharged Franklin engine, has the military designation of OH-13K, formerly the H-13K.

In February 1961, in this helicopter, Dora Dougherty set up two women's records: altitude without payload and non-stop distance in a straight line. The record figures were respectively 19,386 feet and 405·83 miles (5,908·86 metres and 653·12 kilometres).

1960 47G-3B (OH-13S)

This model is powered by an engine equipped with an AiResearch T11 exhaust-driven supercharger. This enables it to maintain its normal rating power up to very high altitudes. The first deliveries to the U.S. Army as an observation and reconnaissance helicopter took place in 1961 under the designation of OH-13S.

Engine: Lycoming TVO-435-A1A, 260 h.p.
Length: 32 ft 8 in (9·96 m)
Width: 8 ft 8 in (2·64 m)
Height: 9 ft 4 in (2·85 m)
Rotor diameter: 37 ft 2 in (11·33 m)
Weight empty: 1,936 lb (878 kg)
Weight fully loaded: 2,850 lb (1,293 kg)
Cruising speed: 88 m.p.h. (142 k.p.h.)
max: 105 m.p.h. (169 k.p.h.)
Inclined climb: 1,190 ft/min (363 m/min)
Service ceiling: 18,000 ft (5,486 m)
Range: 324 miles (521 km)
Number of seats: 3

1962 47G-3B-1

Powered by a Lycoming engine with an AiResearch T11 supercharger giving 270 h.p. at take-off and 220 h.p. in continuous operation, this helicopter has a two-bladed, high-inertia rotor with hydraulic servo-control of cyclic and collective pitch. Its special suitability for air work, cargo transport, reconnaissance and high mountain flight led to the British Army's use of this light helicopter for general purposes, reconnaissance, liaison and training. The British firm of Westland acquired a licence to manufacture it from the Agusta-Bell Company of Italy. The turbocharged 47G-3B-2 is an improved version of the 47G-3B-1.

Engine: Lycoming TVO-435-B1A, 270 h.p.
Length: 31 ft 6 in (9·6 m)
Width: 8 ft 8 in (2·64 m)
Height: 9 ft 4 in (2·85 m)
Rotor diameter: 37 ft 2 in (11·33 m)
Weight empty: 1,790 lb (812 kg)
Weight fully loaded: 2,950 lb (1,338 kg)
Cruising speed: 86 m.p.h. (138 k.p.h.)
max: 105 m.p.h. (169 k.p.h.)
Inclined climb: 905 ft/min (276 m/min)
Service ceiling: 20,000 ft (6,096 m)
Range: 273 miles (439 km)
Number of seats: 3

1964 TH-13T

This two-seater variant of the Bell 47G-3B-1 is a basic instrument trainer, of which 103 are in service with the U.S. Army. The instrument-training gear takes the place of the third seat.

1962 47G-4

This member of the 47G family is powered by a 305 h.p. engine derated to a maximum of 220 h.p. in continuous operation and of 260 h.p. at take-off. It can carry, in addition to the pilot and two passengers, two casualties on stretchers fitted in outside holders.

Engine: Lycoming VO-540-B1B, 305 h.p., derated to 260 h.p. at t.o.
Length: 31 ft 6 in (9·6 m)
Width: 8 ft 8 in (2·64 m)
Height: 9 ft 4 in (2·85 m)
Rotor diameter: 37 ft 2 in (11·33 m)
Weight empty: 1,777 lb (806 kg)
Weight fully loaded: 2,650 lb (1,202 kg)
Cruising speed: 87 m.p.h. (140 k.p.h.)
max: 105 m.p.h. (169 k.p.h.)
Inclined climb: 900 ft/min (274 m/min)
Service ceiling: 14,000 ft (4,267 m)
Range: 312 miles (502 km)
Number of seats: 3

1965 47G-4A

First deliveries of this utility replacement for the 47G-4 were made in December 1965. This helicopter is used not only in the United States but also in Canada, South America and South Africa. It is fitted with extra fuel tanks and with a synchronized elevator.

1965 47G-5

The Bell 47G-5 is a utility helicopter featuring low empty weight and a high payload. It was designed on the principle of eliminating all non-essential structures and components so as to increase its weight-lifting capabilities.

The 47G-5 is available in two versions: a three-seater versatile all-purpose commercial helicopter, well within the range of smaller companies; and a two-seater agricultural version, the Ag-5, with a payload of 1,300 pounds (590 kilos).

The first deliveries of both versions started in January 1966.

1954 BELL 47H BELLAIRUS

This model marked Bell's return to a streamlined and entirely enclosed design. Its metal monocoque tail boom contains a baggage compartment

47G-5

big enough to take all the luggage carried by those travelling in this three-seater. The cabin's width has been increased to 5 feet (1·52 metres), so that motor-vehicle-size seats can be used.

Engine: Franklin 6V4-200-C32, 200 h.p.
Length: 31 ft 4 in (9·55 m)
Height: 9 ft 2 in (2·79 m)
Rotor diameter: 35 ft 1½ in (10·71 m)
Weight empty: 1,490 lb (676 kg)
Weight fully loaded: 2,350 lb (1,066 kg)
Cruising speed: 90 m.p.h. (145 k.p.h.)
max: 100 m.p.h. (161 k.p.h.)
Inclined climb: 900 ft/min (274 m/min)
Range: over 200 miles (over 322 km)
Number of seats: 3

1955 47J (HUL-1, HUL-1G, H-13J) RANGER

This is a modified Model G with a cabin for four persons: the pilot in front, and three passengers behind on a bench. The latter could be removed to make room for two stretchers and a detachable tip-up seat for a nurse. Among the fittings is an electric winch for use in rescue work.

All the mechanical parts are the same as in the 47G-2.

One noteworthy feature is that the welded tube tail is replaced in the 47J by a monocoque beam. The central section is still made of tubes, but it is now streamlined, which makes this the second streamlined commercial model launched by Bell.

The 47J Ranger is the first helicopter to have crossed the Andes by way

47H

of the Christo Paso. This flight was made at a height of 17,000 feet (5,182 metres), with a total weight of approximately 150 pounds (68 kilos) below the helicopter's own maximum gross weight.

The following designations are in use: Navy, HUL-1; Coast Guard, HUL-1G; Air Force, H-13J.

Engine: Lycoming VO-435-A1B, 220 h.p.
Length: 32 ft 4 in (9·86 m)
Width: 7 ft 6 in (2·29 m)
Height: 9 ft 4 in (2·85 m)
Rotor diameter: 37 ft 2 in (11·33 m)
Weight empty: 1,640 lb (744 kg)
Weight fully loaded: 2,565 lb (1,163 kg)
Cruising speed: 99 m.p.h. (159 k.p.h.)
max: 105 m.p.h. (169 k.p.h.)
Inclined climb: 840 ft/min (256 m/min)
Service ceiling: 12,200 ft (3,719 m)
Range: 257 miles (414 km)
Number of seats: 4

1961 HUL-1M

HUL-1M relates to two HUL-1s modified in 1959 under a Navy contract to take an Allison T63 turbine. Tests of these experimental rotorcraft took place during 1962.

47J

1959 47J-2 RANGER

This model resembles the 47J except for a Lycoming engine of 305 h.p. derated to 260 h.p. There are three different versions. One is executive, the second utility, the third a cargo carrier. The transformation to the latter is achieved by removing seats to give 57 cubic feet (1·75 cubic metres) of cargo space.

Engine: Lycoming VO-540-B1B3, 260 h.p.
Length: 32 ft $4\frac{3}{4}$ in (9·88 m)
Width: 7 ft 6 in (2·29 m)
Height: 9 ft 4 in (2·85 m)
Rotor diameter: 37 ft 2 in (11·33 m)
Weight empty: 1,730 lb (785 kg)
Weight fully loaded: 2,850 lb (1,293 kg)
Cruising speed: (max.) 105 m.p.h. (169 k.p.h.)
Inclined climb: 950 ft/min (290 m/min)
Ceiling: 12,100 ft (3,688 m)
Range: 260 miles (418 km)
Number of seats: 4

1964 47J-2A

This four-seater, designed for executive transport, has an engine of the same power as the 47G-4, i.e. 305 h.p. derated to 260 h.p.

Engine: Lycoming VO-540-B1B3, 260 h.p.
Length: 32 ft 4 in (9·86 m)
Width: 8 ft 4 in (2·54 m)

Height: 9 ft 4 in (2·85 m)
Rotor diameter: 37 ft 2 in (11·33 m)
Weight empty: 1,883 lb (854 kg)
Weight fully loaded: 2,950 lb (1,338 kg)
Cruising speed: 97 m.p.h. (156 k.p.h.)
max: 105 m.p.h. (169 k.p.h.)
Inclined climb: 870 ft/min (265 m/min)
Service ceiling: 12,000 ft (3,658 m)
Range: 288 miles (463 km)
Number of seats: 4

47J-2A

1958 47K (HTL-7)

Bell designate as 47K the HTL-7, the United States Navy's first integrated instrument helicopter trainer. This aircraft is designed to give pilots both basic and instrument training.

Engine: Lycoming VO-435-6A, 240 h.p.
Length: 32 ft 4 in (9·86 m)
Height: 9 ft 4 in (2·85 m)
Rotor diameter: 37 ft 2 in (11·33 m)
Weight empty: 1,916 lb (869 kg)

Weight fully loaded: 2,565 lb (1,163 kg)
Cruising speed: (max.) 103 m.p.h. (166 k.p.h.)
Range: 154 miles (248 km)
Number of seats: 2

1963 WING DING

This is an experimental model, developed from the 47J. A modified helicopter, with a wing-span of 25 feet (7·62 metres), it carries two 15-gallon fuel tanks attached one to each wing tip. The wings have conventional flaps and ailerons and, in addition, a movable elevator surface. The aircraft is powered by a Lycoming VO-435 engine, and the rotor mast can be inclined during flight to gain extra speed. It has a four-wheel undercarriage.

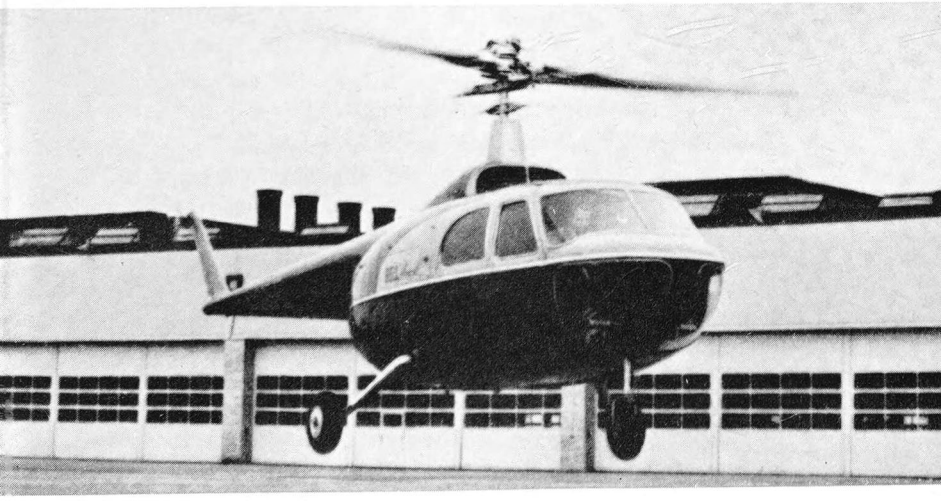
This experimental model is being used to investigate the possibilities of combining the manœuvrability of a helicopter with the load-carrying capabilities of a fixed-wing craft.

During flight tests the Wing Ding has reached speeds of up to 100 m.p.h. (161 k.p.h.).

1945 MODEL 42

Three of these all-metal five-seater helicopters were built, in which the three passengers sat behind the seats for pilot and co-pilot.

Engine: Pratt and Whitney Wasp Junior R-985, 450 h.p.
Rotor diameter: 47 ft 6 in (14·48 m)
Weight empty: 3,655 lb (1,658 kg)



MODEL 42

Weight fully loaded: 5,100 lb (2,313 kg)
Cruising speed: 100 m.p.h. (161 k.p.h.)
Absolute ceiling: 13,000 ft (3,962 m)
Range: 300 miles (483 km)
Number of seats: 5

1949 MODEL 48 (H-12B)

This medium-weight rotorcraft, in the same class as the Sikorsky S-55, was built for the United States Air Force. It was an extrapolation of the Bell 47 with an identical rotor and stabilizing system, but the cabin was wide enough to carry up to ten passengers.

In addition, the seats could be removed to leave room for six stretchers, loaded on laterally by a side door on the right-hand side.

A total of fourteen of these rotorcraft were built for the United States Air Force. The first flight of the first production model took place in November 1949.

Engine: Pratt and Whitney R-1340-55, 600 h.p.
Length: (overall) 58 ft 10 in (17·93 m)
Height: 14 ft 4 in (4·37 m)
Rotor diameter: 47 ft 6 in (14·48 m)
Weight empty: 4,200 lb (1,905 kg)
Weight fully loaded: 6,600 lb (2,994 kg)
Cruising speed: 85 m.p.h. (137 k.p.h.)
max: 110 m.p.h. (177 k.p.h.)
Inclined climb: 1,000 ft/min (305 m/min)
Absolute ceiling: 10,000 ft (3,048 m)
Range: 400 miles (644 km)
Number of seats: 10

1950 MODEL 54 (XH-15)

Three Model 54s were built under the United States Air Force designation of XH-15. The outward appearance of this helicopter, designed for observation and liaison duties, photographic work or inspection of power lines was that of a scaled-down Model 48.

Engine: Continental O-470-5, 275 h.p.
Length: (overall) 43 ft 9 in (13·33 m)
Rotor diameter: 37 ft 4 in (11·38 m)
Weight empty: 2,000 lb (907 kg)
Weight fully loaded: 2,777 lb (1,259 kg)
Cruising speed: 80 m.p.h. (129 k.p.h.)
Absolute ceiling: 20,000 ft (6,096 m)
Range: 400 miles (644 km)
Number of seats: 2 (crew)

MODEL 48

1953 MODEL 61 (HSL-1)

This, the company's biggest helicopter, was built for anti-submarine work with the United States Navy, and by virtue of its two-rotor configuration was Bell's first departure from the single main rotor found on all its other helicopters from the first experimental design.

The two two-bladed rotors (the blades can fold to facilitate storage on board ship) were of the customary Bell type with a stabilizer bar at the hub, and were powered by a Pratt and Whitney radial engine. The transmission shaft ran along the roof of the narrow fuselage, which was flatter than usual.

The helicopter was fitted with the latest dipping sonar devices for submarine detection. It also embodied a new Bell-designed automatic pilot giving better co-ordination than manual control, especially for flights in turbulent conditions or requiring very strict accuracy. This system included a G-2 gyro-compass.

The tests of the automatic pilot, which became standard equipment on the HSL-1, were carried out during the development period on the H-12B.

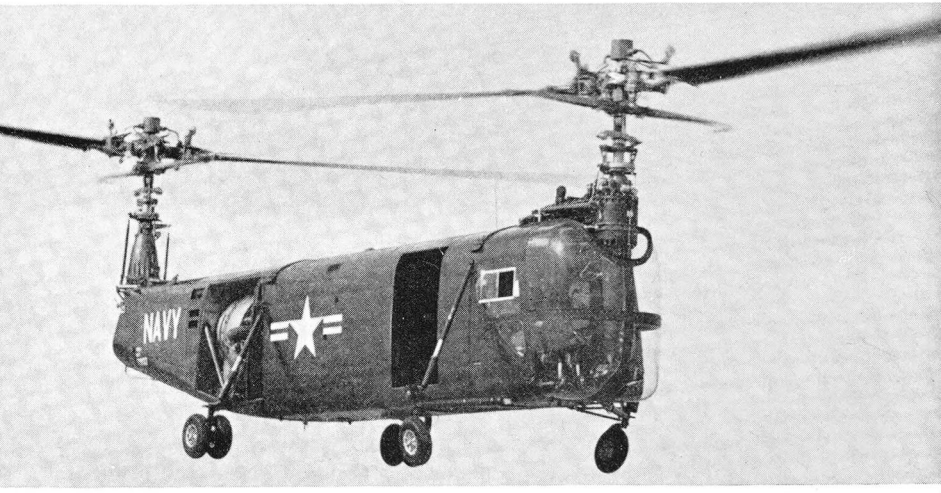
The HSL-1's great stability in flight was due to two factors: its high inertia system, and the accelerometer developed by Bell, which automatically adjusts pitch to offset gusts of winds and either upward or downward streams of air.

These helicopters can carry a crew of four, two pilots and two sonar operators, for a maximum period of 3 hours 30 minutes. For anti-submarine operations, in which they work singly or in pairs, they carry a guided missile designed for underwater targets.

The maiden flight took place in March 1953.

Engine: Pratt and Whitney R-2800-50, 2,400 h.p.

Rotor diameter: 51 ft 6 in (15·7 m)
Weight: 26,500 lb (12,020 kg)
Cruising speed: 100 m.p.h. (161 k.p.h.)
Range: 350 miles (563 km)
Number of seats: 4 (crew)



MODEL 61 (HSL-1)

1955 MODEL 200 (XV-3)

Bell's interest in the convertiplane had been proved by the research work which Arthur Young and Robert Lichten carried out towards the end of the war. From 1944 onwards investigations were made into a two-bladed rotor 30 inches (76 centimetres) in diameter with collective and cyclic pitch control, powered by an electric motor and used in conjunction with a rectangular wing measuring 30 by 6 inches (76 by 15 centimetres).

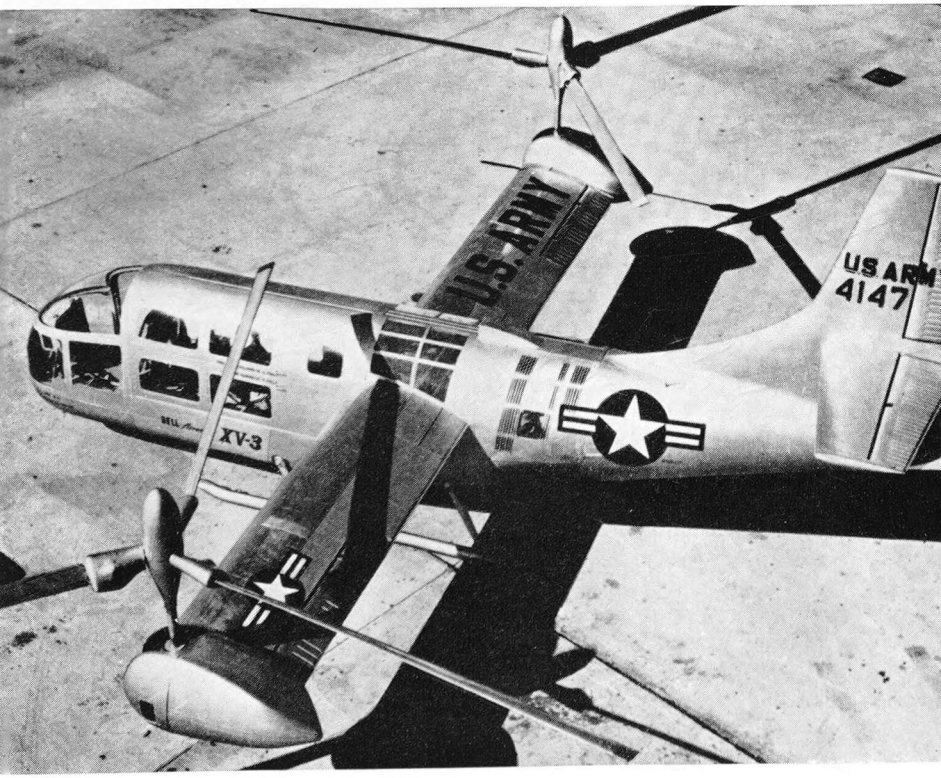
In 1951 Bell, with co-operation from the United States Air Research and the Development Board for the United States Army, designed a medium-range convertiplane. This rotorcraft has the appearance of a 30-foot (9·14-metre) span mid-fixed-wing aircraft. The tips of this extended rectangular wing include housings to take the rotary mechanism for the tilting three-bladed rotors. The latter enable the aircraft to take off like a helicopter, and by turning through 90 degrees when facing forward they act like oversized airscrews.

The change-over from the helicopter to the fixed-wing position takes

some fifteen seconds, and there is no loss of height. The operation can furthermore be stopped or reversed at any given point without upsetting balance. In the event of engine failure, the rotors immediately revert to the helicopter position where they turn by auto-rotation and enable the aircraft to land helicopter-fashion.

This convertible, of which the original military designation XH-33 was later changed to XV-3, first flew in the helicopter position in August 1955.

Engine: Pratt and Whitney R-985, 450 h.p.
Length: 30 ft (9·14 m)
Span: 30 ft (9·14 m)
Height: 13 ft (3·96 m)
Rotor diameter: 24 ft (7·32 m)
Cruising speed: 175 m.p.h. (282 k.p.h.)
Number of seats: 4



MODEL 200 (XV-3)

1956 MODEL 204 (UH-1A, B, C, E, F) IROQUOIS

This helicopter made its maiden flight on 22 October 1956 when it was designated XH-40 and proved the winner of a United States Army utility design competition. It is powered by the Lycoming XT53—the first free-turbine designed specially for helicopter use by Lycoming and the United States Army. This new shaft-turbine helicopter has the following advantages over similar utility helicopters driven by reciprocal engines: empty weight reduced by 35 per cent; payload increased by 100 per cent; speed increased by 43 per cent. Both the engine and the XH-40 itself were sponsored by the United States Army under a contract administered by the United States Air Force.

The low silhouette design places the cabin floor at knee-height, greatly facilitating the loading of cargo, stretchers or troops. Wide sliding doors provide direct access to the cabin compartment.

This helicopter uses the Bell underslung feathering-axis rotor hub, while the two interchangeable rotor blades are made of extruded aluminium spars and laminates. Aft there is a two-bladed tail rotor with internal honeycomb structure and a synchronized stabilizer integrally connected to the cyclic control.

Various designations were used: XH-40 for three experimental models, YH-40 for six service test aircraft and UH-1 Iroquois for the production model.

Engine: Lycoming T53-L-11, 1,100 s.h.p.
Length: 42 ft 8 in (13 m)
Width: 8 ft 3 in (2·51 m)
Height: 12 ft 7 in (3·84 m)
Rotor diameter: 44 ft (13·41 m)
Weight empty: 4,519 lb (2,050 kg)
Weight fully loaded: 8,500 lb (3,856 kg)
Cruising speed: 124 m.p.h. (200 k.p.h.)
max: 138 m.p.h. (222 k.p.h.)
Inclined climb: 2,350 ft/min (716 m/min)
Service ceiling: 17,700 ft (5,395 m)
Range: 212 miles (341 km)
Number of seats: 8–10

Since 1958 this rotorcraft has been produced on a very large scale. In its various forms it is in use with the armed services of more than twenty nations. Each successive variant includes either further innovations or improved performance.

The following are the variants of the 204:
1958 UH-1 (formerly HU-1) U.S. Army.
1959 UH-1A U.S. Army. The 173 units produced from June 1959 to June 1961 were superseded in production by the UH-1B.

XH-40

The three-seater version is used as an instrument trainer. A utility version carries two pilots and five troops and 140 cubic feet (about 4 cubic metres) of cargo.

The engine is a Lycoming T53-L-1A of 860 s.h.p. flat-rated to 770 s.h.p.

1961 UH-1B. U.S. Army 'Iroquois'. In production from March 1961 to July 1966 and superseded by the UH-1C.

On operational duties in Vietnam it has been used for fire support, troop lift (9 seats), medical evacuation and cargo lift.

The power-plant is either a Lycoming T53-L-5, 960 s.h.p., or a Lycoming T53-L-9 and T53-L-11, of 1,100 s.h.p.

1965 UH-1C went into production in 1965. Its capacities and duties are the same as those of the UH-1B. The UH-1C is fitted with a Model 540 rotor of the 'door-hinge' type, a Bell rotor development reducing vibration and component fatigue.

1963 UH-1E, used in particular by the U.S. Marine Corps. The version with standard rotor went into production in February 1964; the version with the 540 rotor in August 1965.

Seating capacity:

on transport duties, 9,
on suppressive fire duties, 2 pilots and 2 gunners,
on rescue duties, 2 pilots, 1 crewman.

The power-plant is a Lycoming T53-L-11.

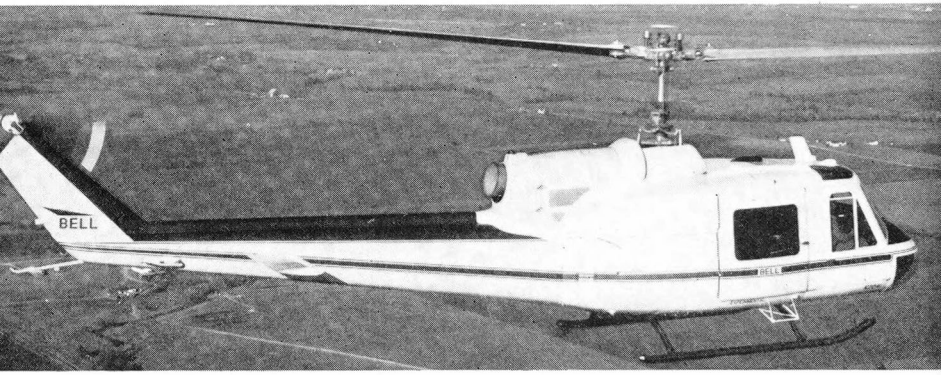
1963 UH-1F. This is an 11-seater U.S. Air Force version of the UH-1 series. The UH-1F is equipped not with a Lycoming but with a General Electric T58-G-3 turbine rated at 1,325 s.h.p. Apart from a standard

hub, the rotor system differs from the U.S. Army UH-1. The rotor's diameter is 48 feet (14·63 metres) or 4 feet (1·22 metres) longer than the Army version and with a lengthened tail boom. The UH-1F has a service ceiling exceeding 22,000 feet (6,706 metres) and a gross weight of 9,000 pounds (4,082 kilos).

It went into production in July 1964 and is now flown by units of the U.S. Strategic Air Command, supporting ICBM sites all over the United States. A variant designated TH-1F is used for instrument training and medical evacuation.

1962 MODEL 204B

The 204B designates the 10-seater civil version of Model 204. It is used mainly as an executive helicopter and for passenger or cargo transport. The first deliveries of this version, which is also built under licence in Italy and Japan, go back to April 1963.



204B

1962 MODEL 205 (UH-1D) IROQUOIS

This improved version of Model 204 is the U.S. Army's standard utility tactical transport helicopter. It has a lengthened cabin and greater fuel capacity in repositioned tanks ensuring more passenger accommodation. During 1964 the UH-1D broke a number of world records, particularly for distance over a closed circuit and in a straight line, speed and rate of climb up to 3,000, 6,000 and 9,000 metres (see list of world records at the end of this book). This helicopter is in active service in Vietnam.

A 15-seater variant, the UH-1D is being produced under an agreement between Bell and the Federal Republic for the West German Army, Navy and Air Force.

The most frequent duties are as follows: troop lift with 2 pilots, 11 men; medical evacuation: 2 pilots, 1 attendant, 6 stretchers; and cargo

of up to 220 cubic feet (over 6 cubic metres) internally, externally 4,000 pounds (1,814 kilos).

Various power plants are fitted to this helicopter, which entered into production in May 1963: Lycoming T53-L-9, 1,100 s.h.p.; T53-L-11, 1,100 s.h.p. or T53-L-13, 1,400 s.h.p., flat-rated to 1,100 s.h.p.

Engine: Lycoming T53 variants (see above)
Length: 44 ft 6 in (13·56 m)
Width: 8 ft 3 in (2·51 m)
Height: 13 ft 4 in (4·06 m)
Rotor diameter: 48 ft (14·63 m)
Weight empty: 4,717 lb (2,140 kg)
Weight fully loaded: 9,500 lb (4,309 kg)
Cruising speed: 124 m.p.h. (200 k.p.h.)
max: 138 m.p.h. (222 k.p.h.)
Inclined climb: 2,350 ft/min (716 m/min)
Service ceiling: 22,000 ft (6,706 m)
Range: 315 miles (507 km)
Number of seats: 12–15

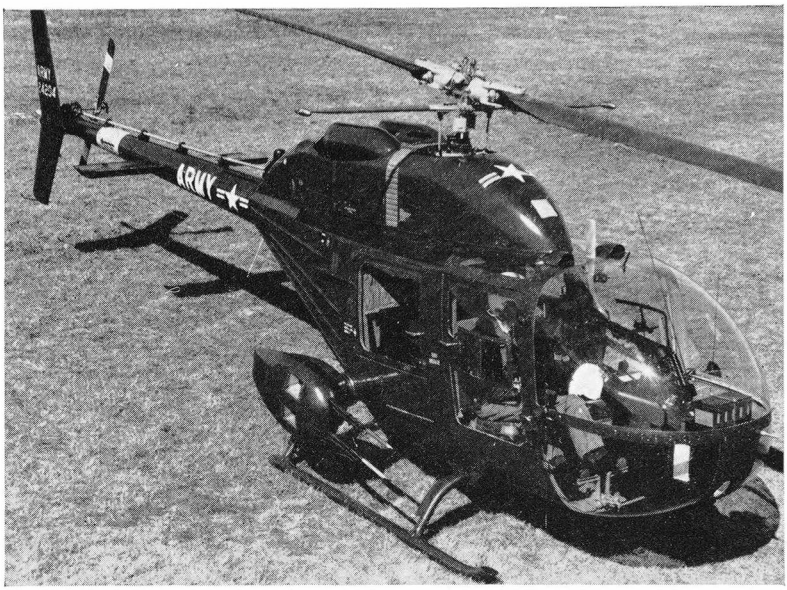
1962 MODEL 206 (OH-4A)

Model 206 was designed to take part in the United States Light Observation Helicopter Competition along with the Hiller OH-5A and the Hughes OH-6A.

It is a light-weight turbine-powered helicopter, which originally used the Bell variable-ratio stabilizer bar on the main rotor, but this feature has since been dropped. The cabin is stressed to withstand 15*g* vertically and 8*g* laterally. The main transmission includes a free-wheeling clutch mounted on the engine output which drives shafts forward to the main box and backwards to the tail gearbox. The number of gears is considerably lower than in the Bell OH-13.

The OH-4A made its maiden flight on 8 December 1962. It was not selected for tender at the end of the U.S. Army Light Observation Helicopter evaluation tests, but was later successful in the second LOH Competition, and took the new designation: OH-58A.

Engine: Allison T63-A-5, 250 s.h.p.
Length: (fuselage) 30 ft 1 in (9·17 m)
Width: 6 ft 8 in (2·03 m)
Height: 8 ft 10 in (2·69 m)
Rotor diameter: 33 ft 4 in (10·16 m)
Weight empty: 1,500 lb (680 kg)
Weight fully loaded: 2,500 lb (1,134 kg)
Cruising speed: 120 m.p.h. (193 k.p.h.)
Range: 350 miles (563 km)
Number of seats: 4



MODEL 206 (OH-4A)

1965 MODEL 206A JET RANGER

The five-seater Jet Ranger jet helicopter is the outcome of development work done by Bell on its OH-4A. The airframe structure consists of one-inch (2·54-centimetre) thick aluminium alloy honeycomb-bonded panels.

The engine, an Allison Model 250 gas-turbine—a civil version resembling the T63-A-5—is placed behind the mast above the passenger compartment.

This multi-purpose helicopter's comfort and speed make it ideal for executive transport, charter work and cargo haulage. The first quantity production deliveries were made in January 1967.

During the first quarter of 1968, the U.S. Army put in a very large order for the Jet Ranger for use as a light observation helicopter. The U.S. Navy, also, uses it as a training version under the designation TH-57.

Engine: Allison 250-C18, 317 s.h.p.
Length: (fuselage) 38 ft 9½ in (11·83 m)
Width: (overall) 6 ft 3½ in (1·92 m)
Height: (overall) 9 ft 6½ in (2·91 m)
Rotor diameter: 33 ft 4 in (10·16 m)
Weight empty: 1,295 lb (587 kg)

Weight fully loaded: 2,900 lb (1,315 kg)
Cruising speed: 140 m.p.h. (225 k.p.h.)
Rate of climb: 2,500 ft/min (762 m/min)
Service ceiling: 20,000 ft (6,096 m)
Range: 5 hours (endurance)
Number of seats: 5

1963 MODEL 207 SIOUX SCOUT

This experimental helicopter is designed to be armed for tactical combat duties. It is derived from the Bell OH-13 of which it has the rotor assembly and engines, together with the centre section and tail boom of the commercial 47J-2. The forward section of the narrow streamlined fuselage can accommodate a two-man crew in tandem: in front the gunner; behind and above, the pilot. Below the gunner is placed a turret with two guns swivelling 200 degrees in azimuth—15 degrees above the horizon and 45 degrees below it.

The 207 has stub wings which can also be used as a platform for additional armament. It is powered by a Lycoming 260 h.p. turbocharged TVO-435-A1A; the two-bladed rotor is of the 'door-hinge' type.

MODEL 207 SIOUX SCOUT

1965 MODEL 208

Model 208, basically a UH-1D, is a twin-turbine prototype, the test flights of which were completed in December 1965. The twin power-plant, consisting of two 800 s.h.p. free-turbine engines with a single coupling gearbox, fits the deckwork on the UH-1D designed for the single Lycoming T53. The Model 208's power-plant combines two Continental T67-T-1 turbines as a unit of 1,600 s.h.p., flat-rated to 1,250 s.h.p. at take-off and 1,100 s.h.p. in continuous flight.

Bell's licensee in Italy, Agusta, has also developed a twin-turbine helicopter of the same class, the Agusta Bell 205TA, with two Turboméca Astazou X turbines.

1965 BELL 209 (AH-1G HUEYCOBRA)

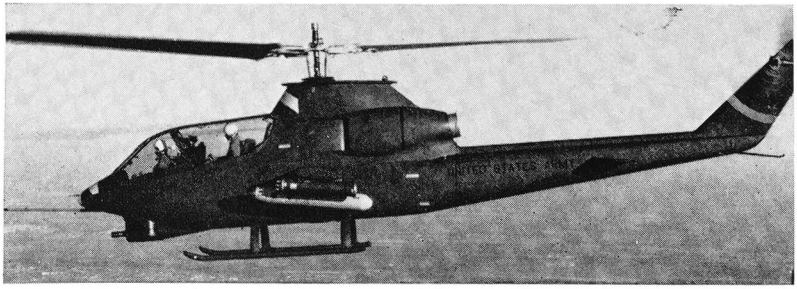
The HueyCobra, which made its maiden flight in September 1965, is an advanced version of the Bell UH-1 series. This high-speed, streamlined-configuration helicopter was designed as an aerial weapons platform to fulfil U.S. Army aerial fire-support and flight-escort duties. Operational since 1967, it is intended to replace the UH-1C.

The HueyCobra embodies the UH-1's dynamic components and other significant maintenance parts. The rotor has a 540 'door-hinge' hub without a stabilizing bar. In the rear, behind the tandem seats, is a small stub wing beneath which can be fitted, for example, four pods containing 76 rockets; in the front, where the gunner sits, an integrated gun turret is located under the nose. In addition, 290 pounds (132 kilos) of advanced armour materials have been integrated with the airframe structure to protect crew and vital components.

The engine, a T53-L-13, resembles that powering one version of the UH-1D.

Engine: Lycoming T53-L-13, 1,400 s.h.p.

Length: (fuselage) 44 ft 5¼ in (13·54 m)



BELL AH-1G

Width: (overall) 36 ft (10·97 m)
Height: (overall) 11 ft 7 in (3·53 m)
Rotor diameter: 44 ft (13·41 m)
Weight empty: 5,288 lb (2,399 kg)
Weight fully loaded: 9,500 lb (4,309 kg)
Cruising speed: 168 m.p.h. (270 k.p.h.)
max: 219 m.p.h. (352 k.p.h.)
Number of seats: 2

1968 BELL 212

The general configuration is similar to the 205. The medium twin-jet 212 is a 15-seater helicopter powered by the PT6T-3 'Twin-Pac' engine from United Aircraft of Canada Ltd with combining gear box. The first flight was made in April 1969. The U.S. Air Force designation is UH-1N.
Engines (2)*:* UAC PT6T-3, 1,800 s.h.p. derated to 1,100 s.h.p.
Length: 46 ft 1 in (14·05 m)
Width: 9 ft 1 in (2·77 m)
Height: 13 ft 1 in (3·99 m)
Rotor diameter: 48 ft (14·63 m)
Weight empty: 5,500 lb (12,125 kg)
Weight fully loaded: 10,000 lb (22,046 kg)
Cruising speed: 121 m.p.h. (195 k.p.h.)
Inclined climb: 1,460 ft/min (445 m/min)
Range: 312 miles (502 km)

1955 MODEL 216 (PROJECT)

This model was to be a variant on the anti-submarine HSL-1 designed for transport use.

It was planned to use three turbines placed just forward of the rear rotor and driving both rotors, the front one by a driveshaft above the passenger cabin. The rotors would be of the same type as those used in the HSL-1, but the blades would be longer.
Engines (3)*:* Lycoming T53 turbine
Rotor diameter: 55 ft (16·76 m)
Number of seats: 27

1962 MODEL 533 (YUH-1B)

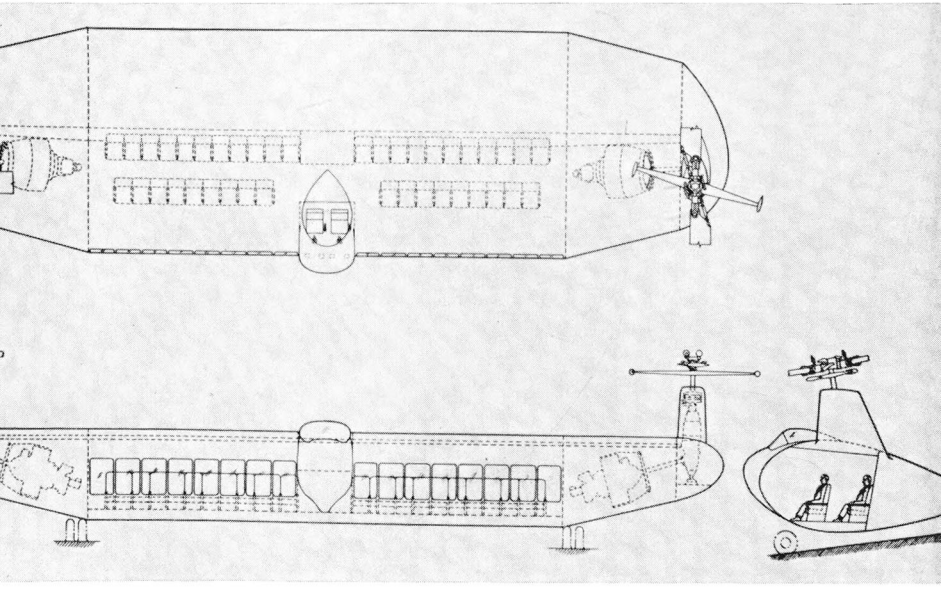
This high-speed research vehicle, which made its maiden flight on 10 August 1962, is a modified UH-1B intended to evaluate drag reduction, various rotor systems, aerodynamic improvements and so on.

Tests have been made with a tilting pylon, tapered rotor blade tips, auxiliary jet engines and later with fixed wings. The compound version helicopter with two Continental J69 auxiliary jet engines on the fuselage in April 1965 reached speeds of the order of 250 m.p.h. (402 k.p.h.) in the course of tests carried out on behalf of TRECOM (United States Army Transportation and Research Command).

On this UH-1 high-performance helicopter several rotor systems have been tested with wing only, or jet only, or else a wing and jet configuration. These rotors are of the following types: three-bladed gimbal rotor, three-bladed and four-bladed rotors and Model 540 with tapered tip. The 1967 programme planned to modify this helicopter by use of a new wing, larger elevators and rudder and two JT12-A3 auxiliary engines each rated at 2,900 pounds (1,315 kilos) thrust.

BELL (PROJECT)

This undated, unnumbered project consisted of a kind of harmonica-shaped helicopter or flying wing, with a large rotor at each end intended to give the rotorcraft fast forward speed. The planned engines, Wright R-1820 or Pratt and Whitney R-280, were to be so geared that the rotors might be driven by one engine alone should the other fail. They might



BELL PROJECT

also perhaps be replaced by gas-turbines. In either event, the rotors would have differential lift to even out any uneven loading.

The planned size of this project was approximately that of a Convair 340, and was to carry forty passengers over a distance of 300 miles (483 kilometres). It is likely that experience acquired with the XV-3 convertiplane was to be embodied in this flying wing.

BENDIX

The organization known as Bendix Helicopters Inc. was set up in 1944 by the late Vincent Bendix, well known for his automatic brakes and washing machines, with the aim of developing contra-rotating helicopters. Under this title it produced two models respectively known as Bendix J and Bendix K.

It was later reorganized as Helicopters Inc. and dissolved in 1949, by which time its Model J had logged more than 100 hours' flying time.

1945 MODEL K

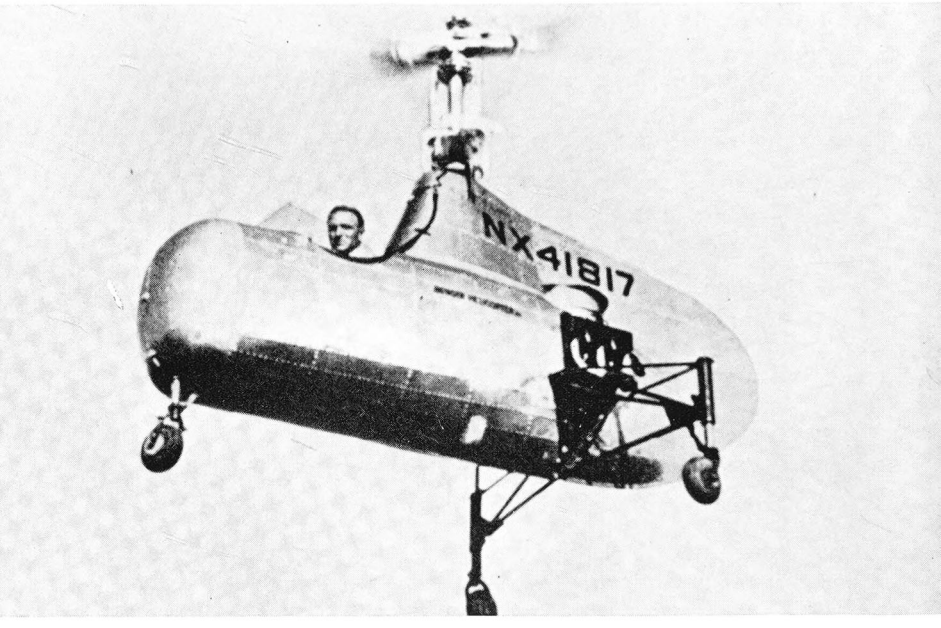
Designed by Martin Jensen, this single-seater prototype was fitted with contra-rotating co-axial two-bladed rotors mounted on two concentric shafts. The distance between the two rotors was 2 feet 4 inches (71 centimetres). In case of engine failure, provision was made for autorotation by means of a freewheeling unit.

Model K, which made its first flights in June 1945, was primarily intended as a flying test stand, and its flights were made essentially to secure data on control, stability and vibration.

Engine: Continental C-100, 100 h.p.
Length: 12 ft 6 in (3·81 m)
Height: 9 ft 9 in (2·97 m)
Rotor diameter: 25 ft (7·62 m)
Weight empty: 807 lb (366 kg)
Weight fully loaded: 1,200 lb (544 kg)
Crusiing speed: 60 m.p.h. (97 k.p.h.)
Inclined climb: 900 ft/min (274 m/min)
Absolute ceiling: 10,000 ft (3,048 m)
Range: 50 miles (80 km)
Number of seats: 1

1947 MODEL J

This experimental machine had a rotor configuration identical with that of Model K. The rotors were 4 feet 6 inches (1·37 metres) apart. Of see-saw type, they had no drag hinges, and the blades were equipped with a centrifugal stop mechanism to control flapping. This model also



MODEL K

incorporated a suspension system of three tension units and four links between the transmission and the fuselage frame.

Engine: Pratt and Whitney R-985, 450 h.p.
Length: 21 ft 3 in (6·48 m)
Height: 14 ft 3 in (4·34 m)
Rotor diameter: 48 ft (14·63 m)
Weight empty: 3,600 lb (1,633 kg)
Weight fully loaded: 5,400 lb (2,449 kg)
Cruising speed: 85 m.p.h. (137 k.p.h.)
Inclined climb: 1,460 ft/min (445 m/min)
Absolute ceiling: 22,100 ft (6,736 m)
Range: 270 miles (435 km)
Number of seats: 4–5

BENSEN

For many years Igor B. Bensen worked with General Electric on experimental rotary-wing aircraft. In particular he was concerned with the GE

Gyro-Glider, developed at the Schenectady Flight Test Center, and also with investigations into jet propulsion.

In 1953 he founded the Bensen Aircraft Corporation which produced various autogyro-type rotorcraft, having no engines and flying behind a towing agent.

1953 MIDJET

This miniature single-seater helicopter, designed as a private venture mainly for use in the United States Navy, has been simplified to such a degree that its components can be reassembled with hand tools.

At each tip of the two-bladed rotor is a ram-jet engine, weighing a mere 5 pounds (2·27 kilos) and running on either ordinary petrol or fuel oil.

The Midjet is reported to be able to lift four times its own weight.

The initial tests were carried out in 1954.

Engines (2)*:* ram-jet, equivalent to 40 h.p.
Rotor diameter: 15 ft (4·57 m)
Weight empty: 100 lb (45 kg)
Weight fully loaded: 500 lb (227 kg)
Cruising speed: 75 m.p.h. (121 k.p.h.)
Number of seats: 1

1955 B-4 SKY-SCOOTER

Bensen's design following his initial Gyro-Glider was a small helicopter with a two-bladed rotor, known as the Sky-Scooter.

The blades are set in motion through a drive system known as HEPARS: 'High Efficiency Propulsion and Rotor System'. This is a single air-cooled engine mounted above the rotor hub and driving two two-bladed airscrews on the rotor blades; there is, consequently, no torque to be counteracted. The rotor is controlled by a suspended stick, the lower end of which ends in motor-cycle handlebars, and there are two rubber pedals for steering to left and right.

If so required, the Sky-Scooter can carry two persons, the passenger being then seated as on the rear seat of a motor-cycle.

Engine: Nelson H-59, 40 h.p.
Rotor diameter: 29 ft (8·84 m)
Weight empty: 340 lb (154 kg)
Weight fully loaded: 720 lb (327 kg)
Cruising speed: 55 m.p.h. (89 k.p.h.)
Inclined climb: 750 ft/min (229 m/min)
Range: 118 miles (190 km)
Number of seats: 1–2

1954 B-6 GYRO-GLIDER

This design, a rotary glider, operated in the same way as the Fa-330 used by the Germans during World War II.

The two-bladed rotor was set in motion by hand and the glider was then towed by any means available. The take-off speed is roughly 20 m.p.h. (32 k.p.h.) and the landing speed about 7 m.p.h. (11 k.p.h.), with a forward roll-off of 10–15 feet (3–4·6 metres).

This engineless aircraft remained airborne as long as it was towed or there was enough wind to keep the rotors turning sufficiently.

Since 1965 the B-6 Gyro-Glider has been on exhibition at the Smithsonian National Air Museum in Washington.

Engine: None
Rotor diameter: 29 ft (8·84 m)
Weight empty: 86 lb (39 kg)
Number of seats: 1

1955 B-7 GYRO-GLIDER

This is virtually the same aircraft as the preceding one except that the rotor, instead of being carried by three tubes (one from each side of the back of the pilot's seat, the third from the tip of the foot-rest), is supported by the end of a shortened post.

The method of use is exactly the same as for the B-6.

There is also a version called the B-7 Hydro-Glider, equipped with pontoons suitable for towing over water by a ship.

1956 B-7M GYRO-COPTER

This is a B-7-type Gyro-Glider which, since it is fitted with an engine, can fly under its own power. It has a two-bladed rotor, with a free-wheeling device which allows auto-rotation; the rotor head and blades are the same as those used in the Gyro-Glider. Cyclic control is ensured by an overhead hanging stick.

The airframe of standard aluminium tubing can be easily dismantled; the landing gear is of tricycle type with an auxiliary tail wheel, but if required 'float conversion plans' can be provided.

The power source is a 4-cylinder air-cooled two-cycle engine which drives an airscrew with a diameter of 42 inches (1·07 metres).

In the absence of wind, this machine can take off after a run of 300 feet (91·4 metres), and it runs about 20 feet (6·1 metres) on landing, when its speed is roughly 8 m.p.h. (13 k.p.h.). Its sustentation speed is 19 m.p.h. (31 k.p.h.), and it can turn in a radius of 50 feet (15·24 metres).

The Gyro-Copter can be bought in the form of a kit containing the main components, which can then be assembled with only a few hand tools.

Engine: Nelson H-59, 40 h.p.
Length: 8 ft 7 in (2·62 m)
Width: 5 ft 4 in (1·63 m)
Height: 5 ft 10 in (1·78 m)
Rotor diameter: 20 ft (6·1 m)

Weight empty: 185 lb (84 kg)
Weight fully loaded: 420 lb (191 kg)
Cruising speed: 60 m.p.h. (97 k.p.h.)
min: 15 m.p.h. (24 k.p.h.)
Inclined climb: 950 ft/min (290 m/min)
min. rate of descent: 17 ft/min (5·18 m/min)
Range: 20 minutes (endurance)
Number of seats: 1

1956 B-8 GYRO-GLIDER

This is an improved version of the B-7, and is sold in the form of kits to be used by amateurs. The main structure is of heat-treated aluminium tubing and all the primary structure can be assembled with bolts. The Gyro-Glider must reach a minimum speed of 20 m.p.h. (32 k.p.h.) in order to take off. Its landing speed is about 7 m.p.h. (11 k.p.h.).

Length: 11 ft 4 in (3·45 m)
Width: 5 ft 6 in (1·68 m)
Height: 6 ft 3 in (1·91 m)
Rotor diameter: 20 ft (6·1 m)
Weight empty: 128 lb (58 kg)
Weight fully loaded: 300 lb (136 kg)
Cruising speed: 40 m.p.h. (64 k.p.h.)
Number of seats: 1

1957 B-8M GYRO-COPTER

Intended to be built by amateurs, the B-8M is a basic B-8 Gyro-Glider transformed into an autogyro by an engine driving a pusher propeller 3 feet 9 inches (1·14 metres) in diameter.

The two-bladed rotor, made of laminated wood with a steel spar, revolves at 400 r.p.m.

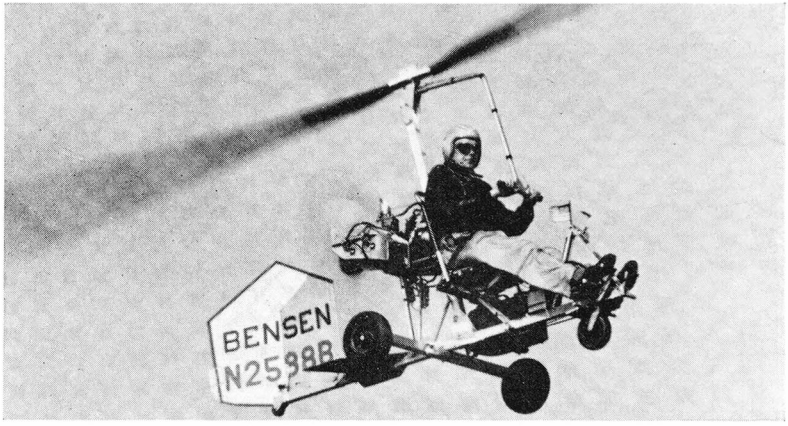
Everything about this rotorcraft has been simplified to the utmost: the structure and the controls, when in flight, are reduced to cyclic, yaw and throttle. Instead of the usual Bensen overhead hanging stick control, a conventional floor-type joystick can be used. On the ground there is a brake for the nose wheel of the landing gear.

In calm air this autogyro can take off in 300 feet (91·4 metres) and land at a speed of about 7 m.p.h. (11 k.p.h.). Its minimum flying speed is around 15 m.p.h. (24 k.p.h.). The minimum rate of descent is 18 feet per second (5·5 metres per second). Several hundred plans and kits for this autogyro have been sold.

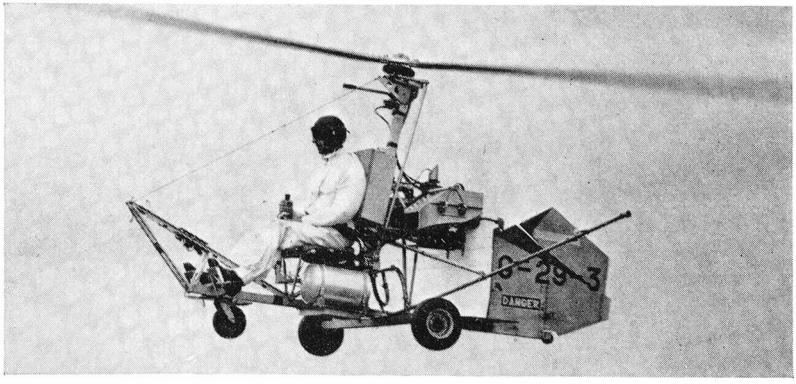
There is a version equipped with pontoons known as the B-8MW Hydro-Copter.

In 1967 the B-8M was the first autogyro to establish records which were officially registered by the F.A.I.

Engine: McCulloch 4318E, 72 h.p.
Length: 11 ft 4 in (3·45 m)
Width: 5 ft 6 in (1·68 m)
Height: 6 ft 3 in (1·91 m)
Rotor diameter: 20 ft (6·1 m)
Weight empty: 247 lb (112 kg)
Weight fully loaded: 500 lb (227 kg)
Cruising speed: 60 m.p.h. (97 k.p.h.)
max: 85 m.p.h. (137 k.p.h.)
Inclined climb: 1,000 ft/min (305 m/min)
Service ceiling: 12,500 ft (3,810 m)
Range: 100 miles (161 km)
Number of seats: 1



B-8M GYRO-COPTER



B-8MW (W/O FLOATS)

B-8MW HYDRO-COPTER

1958 B-9 LITTLE ZIPSTER

The Little Zipster is not an autogyro but a helicopter with co-axial contra-rotating two-bladed rotors. The suspension is equipped with a teeter hinge but no lag hinges. The pilot's controls consist of an overhead hanging stick for cyclic pitch and rudder, foot pedals for yaw, and twist grip on the left handlebar for the throttle. There is no collective control.

The rotors are made of laminated wood with a steel spar, and the main structure is of aluminium tubing. The landing gear is of the tricycle type and the engine is a water-cooled outboard motor.

Engine: Mercury MK-78, 70 h.p.
Length: 11 ft 3 in (3·43 m)
Width: 6 ft (1·83 m)
Height: 8 ft 10 in (2·69 m)
Rotor diameter: 20–22 ft (6·1–6·71 m)
Weight empty: 450 lb (204 kg)
Weight fully loaded: 700 lb (318 kg)
Cruising speed: 60 m.p.h. (97 k.p.h.)
max: 80 m.p.h. (129 k.p.h.)
Inclined climb: 900 ft/min (274 m/min)
Service ceiling: 11,000 ft (3,353 m)
Range: 100 miles (161 km)
Number of seats: 1

1963 B-11

This is a B-8 Gyro-Copter with a few improvements such as a new

gimbal tilting-head azimuth control, bigger blades and an auxiliary engine mounted on top of the rotor pylon, and driving the rotor through an over-running clutch.

Engine: McCulloch 72 h.p. plus West Bend 7 h.p.
Length: 11 ft 4 in (3·45 m)
Height: 6 ft 4 in (1·93 m)
Rotor diameter: 22 ft (6·71 m)
Weight empty: 285 lb (129 kg)
Weight fully loaded: 625 lb (283 kg)
Number of seats: 1

1964 KOPTER-KART

A development of the B-11, this aircraft has, instead of a single propeller, six little airscrews each powered by a small McCulloch Kart engine.

EMILE AND HENRY BERLINER

In 1908 Emile Berliner, who had previously invented a gramophone, a telephone transmitter and numerous other devices, became interested in the problems of helicopter flight. In conjunction with Newton Williams he built a portable stand to which were attached two contra-rotating rotors. An accident caused by one of the blades on this equipment brought the partnership to an end.

In 1913 Berliner conceived what he then called a 'Gyrocopter', but he was unable to test his concepts properly until after the end of World War I.

In 1920 an experimental aircraft made a few hops with Henry Berliner, son of Emile, at the controls.

These first trials were followed by others using aircraft which Henry Berliner built with backing from his father.

The following were the various aircraft produced by Henry Berliner.

The first, built round a Nieuport fuselage, was fitted with outriggers to carry the rotors. Control was ensured by lateral vanes placed in the slipstream of the rotor. The design evolved rapidly and finally became a sort of triplane with a total wing area of 135 square feet (just under 13 square metres), and a system to connect propeller and rotors.

Starting from 1924, this aircraft performed a series of very short flights of which the best known took place on 23 February 1924, when it remained airborne for more than $1\frac{1}{2}$ minutes at a height of 15 feet (roughly 4·6 metres).

This aircraft is now in the collection of the National Air Museum of the Smithsonian Institution.

Engine: Bentley Model 2, 200 h.p.

Length: (overall) 20 ft 6 in (6·25 m)
Height: 6 ft 9 in (2·06 m)
Rotor diameter: 15 ft (4·57 m)
Weight empty: 1,650 lb (748 kg)
Weight fully loaded: 1,918 lb (870 kg)
Wing span: upper: 38 ft (11·58 m)
middle: 34 ft (10·36 m)
lower: 30 ft (9·14 m)

The following year, i.e. 1925, Henry Berliner built yet another aircraft in which the lateral balance, which left much to be desired in the former machine, was improved by putting ailerons on the rotor blades, with the result that a sort of biplane was produced. This model also flew successfully.

Engine: Bentley, 200 h.p.
Length: 30 ft (9·14 m)
Width: (overall) 42 ft (12·8 m)
Rotor diameter: 20 ft (6·1 m)
Weight fully loaded: 1,810 lb (821 kg)

Nevertheless, too many problems in helicopter design still awaited solution, so Henry Berliner went back to fixed-wing aircraft, and with Fred Weick he produced the safe light aircraft 'Ercoupe'.

BOEING VERTOL

In 1960 the Vertol Aircraft Company of Morton, Pennsylvania, became a division of the Boeing Airplane Company of Seattle. At the same time, Allied Research Associates Incorporated, of Boston, Mass., an affiliate of Vertol, also passed under the control of Boeing, together with a Canadian subsidiary, Canadian Vertol Aircraft Company Limited of Arnprior, Ontario. The latter firm continues to work as part of the Vertol Division, which continues its helicopter work under the aegis of Boeing (see Vertol).

BRANTLY

Brantly, a weaving-machinery expert with the Penn Elastic Company, designed and had made by that firm a helicopter with contra-rotating co-axial rotors, the lines of which had a very clean appearance.

Some years after this first attempt, Brantly had another helicopter built, this time with a single rotor and an anti-torque tail rotor. This led to one of the cheapest mass-produced rotorcraft on the American market.

1946 B-1

The B-1 was fitted with two co-axial contra-rotating three-bladed rotors. Neither push rods nor cranks were visible in the rotary-wing assembly. Actually, the collective, cyclic and differential controls were completely enclosed in the hubs and ran in an oil-bath.

A universal joint combining two hinges was situated at some 6 feet (1·83 metres) from the root of the blades. The radius of the non-flapping part of the blades was thus 6 feet (1·83 metres).

Each blade weighed only 12 pounds (5·4 kilos) and the rotors normally turned at 320 r.p.m.

This rotorcraft made its maiden flight in 1946.

Engine: Franklin 335, 150 h.p.
Length: 17 ft 6 in (5·33 m)
Height: 7 ft 9 in (2·36 m)
Rotor diameter: 29 ft 6 in (8·99 m)
Weight empty: 1,325 lb (601 kg)
Weight fully loaded: 2,000 lb (907 kg)
Cruising speed: 95 m.p.h. (153 k.p.h.)
Range: 400 miles (644 km)
Number of seats: 2

1953 B-2

This prototype was a helicopter of conventional type with a three-bladed main rotor and a three-bladed anti-torque tail rotor measuring 3 feet 10 inches (1·17 metres).

One feature of the main rotor was the use of two flapping hinges, one at the root of the blade and the other roughly at the middle. The blades were made of extruded aluminium and the leading edge spar filled with polyurethane foam. The monocoque aluminium fuselage was fully streamlined.

The B-2 flew in February 1953 with a 135 h.p. Lycoming O-290-D2, which was replaced during trials by a Lycoming O-340 developing 170 h.p. In order to avoid the complication of a cooling fan, an induction cooling system was used, taking advantage of the exhaust gases' velocity.

Following the prototype's certification in April 1959, two production versions were marketed. In 1962 came the Brantly B-2A with a redesigned streamlined and enlarged cockpit, to be followed by a variant, the B-2B, with a fuel-injection engine. In both the engine is vertically mounted and develops 180 h.p.

The U.S. Army designation is YHO-3BR.

Engine: Lycoming VO-360, 180 h.p.
Length: 23 ft $8\frac{7}{8}$ in (7·23 m)
Height: 19 ft 4 in (5·89 m)
Width: 5 ft $8\frac{1}{4}$ in (1·73 m)

Rotor diameter: 23 ft 9 in (7·24 m)
Weight empty: 1,020 lb (463 kg)
Weight fully loaded: 1,600 lb (726 kg)
Cruising speed: 100 m.p.h. (161 k.p.h.)
Inclined climb: 1,300 ft/min (396 m/min)
Ceiling: 11,400 ft (3,475 m)
Range: 200 miles (322 km)
Number of seats: 2

B-2

1964 BRANTLY 305

This helicopter with its 200-pound (91-kilo) luggage allowance is an enlarged five-seater version of the B-2, which technically it resembles. The more powerful engine (305 h.p., derated to 250 h.p.) is again mounted vertically and the rotor is on the same principle. There is a tricycle landing gear.

Engine: Lycoming VO-540, 305 h.p., derated to 250 h.p.
Length: 24 ft 7 in (7·49 m)
Height: 7 ft 9 in (2·36 m)
Rotor diameter: 28 ft 6 in (8·69 m)
Weight empty: 1,375 lb (624 kg)

Weight fully loaded: 2,825 lb (1,281 kg)
Cruising speed: 100 m.p.h. (161 k.p.h.)
max: 125 m.p.h. (201 k.p.h.)
Range: 250 miles (402 km)
Number of seats: 5

BUHL

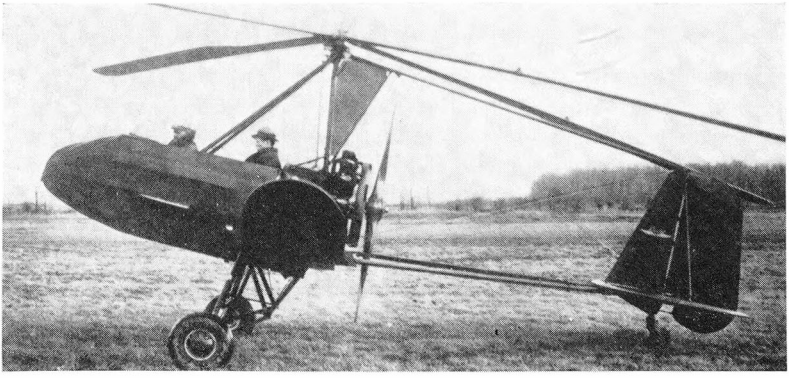
In 1930 the Buhl Manufacturing Company of Detroit acquired a licence from the Autogiro Company of America and used it to construct a 'pusher' autogyro designed for photographic and observational purposes.

1931 BUHL

This prototype was the only autogyro built by this particular company, and also the first 'pusher' autogyro. This configuration ensured the excellent visibility required for the special purposes the aircraft was designed to serve.

The four-bladed rotor was supported by a tripod. The fuselage was in steel tubing with an outrigger system to support the tail surfaces. There was tandem seating accommodation, the front seat being for the pilot.

Engine: Continental, 165 h.p.
Rotor diameter: 47 ft (14·33 m)
Weight empty: 1,400 lb (635 kg)
Weight fully loaded: 2,000 lb (907 kg)
Number of seats: 2



BUHL

CANAMERICAN

The Canamerican Helicopter Manufacturing Company was formed in June 1953 in New York to exploit the patents and rights pertaining to the Canadian-built SG Mark VI, which the American company had acquired from Intercity Airlines of Montreal. The SG-VI flew for the first time on 7 July 1947, but shortly afterwards was stored for a long period and did not take the air again until its final acceptance tests for certification in 1951. As a result it became the first helicopter to obtain the Canadian Certificate of Airworthiness.

Later still, in 1953, it flew again during the negotiations with Canamerican, and though it had then been immobilized for more than a year, its performance in flight astonished the spectators.

The SG-VI-E variant had a more powerful engine than the SG-VI.

1953 SG-VI-E

Engine: Franklin 6A4-200-C6, 200 h.p.
Rotor diameter: 35 ft (10·67 m)
Weight fully loaded: 2,550 lb (1,157 kg)
Number of seats: 3

CAPITAL

Early in 1954 the Capital Helicopter Corporation was formed to exploit properties belonging to Horace Pentecost. Pentecost had, in fact, reacquired his patent rights and severed his connections with Hoppicopter (*q.v.*).

1953 C-1

This small single-seater helicopter, popularly nicknamed 'flivver of the future', had an uncovered body consisting of a welded steel tube structure. The 6-foot (1·83-metre) track tricycle undercarriage had rubber-cord shock-absorbers.

The semi-rigid rotor had two blades, was of see-saw type and was powered by two (U.S.A.) Naval Research Laboratory pulse-jets, one at each blade tip. Each pulse-jet gave a thrust of 23 pounds (10·4 kilos). The blades were supplied by the Brantly Helicopter Corporation.

The C-1 could take off from a 40-foot (12·2-metre) circle, and its 16·6-gallon (75·5-litre) store of fuel contained in a tank placed behind the pilot would keep it airborne for ninety minutes.

Ground tests started late in 1953.

Engines (2)*:* U.S.A. Naval Research Laboratory pulse-jets
Height: 6 ft (1·83 m)

Rotor diameter: 18 ft (5·49 m)
Weight empty: 130 lb (59 kg)
Weight fully loaded: 450 lb (204 kg)
Cruising speed: 60 m.p.h. (97 k.p.h.)
max: 90 m.p.h. (145 k.p.h.)
Inclined climb: 800 ft/min (244 m/min)
Absolute ceiling: 10,000 ft (3,048 m)
Range: 100 miles (161 km)
Number of seats: 1

CAPITOL COPTER

This firm in St Paul, Minnesota, has developed an autogyro intended to be sold in the form of a kit, which can be built either with wheel or with float landing gear.

1959 CAPITOL COPTER

This small, single-seater, two-bladed-rotor autogyro can take off in 400 feet (122 metres) and its landing-run speed is of the order of 10 m.p.h. (16 k.p.h.)
Engine: McCulloch, 72 h.p.
Length: 11 ft 6 in (3·51 m)
Width: 6 ft 9 in (2·06 m)
Rotor diameter: 23 ft (7·01 m)
Weight empty: 390 lb (177 kg)
Weight fully loaded: 690 lb (313 kg)
Cruising speed: 70 m.p.h. (113 k.p.h.)
Range: 215 miles (346 km)
Number of seats: 1

CARSON

Since 1963 Carson Helicopters has been engaged on equipping Bell and Hiller rotorcraft with Franklin 6VS-335 240 h.p. engines and specially on converting the 47G into a four-seater, which Carson designates as the Super C-4.

CESSNA

The Cessna Aircraft Company was founded by Clyde Cessna, who even before World War I was at work in the American aircraft industry.

The company ceased operations during the economic depression of the 1930s, but revived vigorously during World War II, when it produced trainers and utility cargo aircraft for the United States Air Force and the Royal Canadian Air Force, as well as the 750 CGA gliders used in that war.

Following World War II, Cessna brought out several luxury sporting aircraft, the Models 190 and 195, and also, at the end of 1951, the well-known Model 170.

Cessna first took an interest in helicopters when it acquired the patents and rights owned by Seibel (*q.v.*), Seibel himself becoming chief designer of the Cessna Helicopter Division.

1953 CH-1 (YH-41)

This rotorcraft is of all-metal construction, and its lines recall those of Cessna fixed-wing aircraft, while the two-bladed rotor, designed by Seibel, also recalls that of the Seibel helicopter.

The rotor blades are attached to the hub by light-weight stainless steel L-shaped angles, which carry the blades' centrifugal load: the short leg takes up the loads due to blade weight, the long leg the bending load caused by drag. As in the Seibel helicopter, this assembly not only provides angle movement for changing blade pitch but also eliminates trunnions, thrust bearings, hinges, etc.

The supercharged engine is placed in the forepart of the fuselage, thus leaving more space for cargo or passengers in the cabin, which is that of a fixed-wing aircraft.

The first prototype flew in July 1953. In 1955 a CH-1 successfully landed on, and took off from, Pike's Peak, Colorado, at a height of 14,100 feet (4,300 metres).

The CH-1 was followed by the CH-1A, with the same general design but four seats instead of two.

The CH-1B featured a different engine, a 270 h.p. Continental FSO-526-A. In an aircraft of this type on 28 December 1957 at Wichita, Kansas, Captain James E. Bowman set up an altitude record for rotorcraft weighing from 1,000 to 1,700 kilos by reaching a height of 9,076 metres.

The CH-1C or 'Skyhook' appeared in 1959. In 1960, its instrumented version became the first rotary-wing aircraft to receive the Federal Aviation Agency's approval for IFR flight. The CH-1C is a 4-seater.

The CH-1D, with an increase in gross weight of 100 pounds (45.4 kilos) over the CH-1C, has been available since 1962 in three versions: personnel transport, utility model and a 'municipal' version designed for Civil Defence use.

The military designation is YH-41.

Engine: Continental FSO-470-A, 260 h.p.

Length: (fuselage) 32 ft 1 in (9·78 m)
Width: (fuselage) 6 ft 4 in (1·93 m)
Height: (overall) 8 ft $3\frac{3}{4}$ in (2·54 m)
Rotor diameter: 35 ft (10·67 m)
Weight empty: 1,975 lb (896 kg)
Weight fully loaded: 3,000 lb (1,361 kg)
Cruising speed: 100 m.p.h. (161 k.p.h.)
max: 122 m.p.h. (196 k.p.h.)
Inclined climb: 1,150 ft/min (351 m/min)
Range: 290 miles (467 km)
Number of seats: 2

CH-1

CONTINENTAL COPTERS

This helicopter contract firm operates in the same place as Bell, with which, however, it is unconnected. From earlier Bell 47 models Continental Copters has produced the 'El Tomcat', a helicopter designed specially for spraying.

The main change is a redesigned forward cabin with a smaller frontal area than Model 47, making the Tomcat a single-seater. The first 'El Tomcat', which was equipped with a 210 h.p. Franklin engine, was succeeded in 1965 by a version with a more powerful 235 h.p. Franklin able to carry a sprayload of 90-120 gallons (409-546 litres).

CONVERTAWINGS

Convertawings has revived the concept tried out in 1922 in France by

Oemichen, lift for whose helicopter was provided by four rotors, and by G. de Bothezat in the United States, with a double side-by-side arrangement of four rotors embodied in the first helicopter ordered by the United States Army, which flew in 1923.

As the result of Convertawings' further developmental work on this configuration, a first prototype was completed in 1955 and it has since flown successfully. D. H. Kaplan, who had been a test engineer with Piasecki and a development engineer with Doman before founding Convertawings, is considering the possibility of developing two further helicopters on similar lines.

1955 MODEL A

The four rotors of this helicopter are mounted laterally on outriggers in two tandem pairs.

The control mechanism is extremely simplified and obtained by differential change of thrust between the rotors. There is no cyclic control, but only collective control.

In the experimental prototype the fuselage was of tubular steel, the booms supporting the rotors in aluminium alloy. Power was provided by two engines connected to the rotor drive system by multiple vee-belts. Shafting and transmission cases ensured interconnection between the four rotors, so that, if necessary, either engine could drive all of them.

There is a tricycle undercarriage with two wheels in the rear section and a nose wheel which can swivel.

The first flights took place in March 1956.

Engines (2)*:* Continental C90, 90 h.p.
Rotor diameter: 19 ft 5 in (5·92 m)
Weight fully loaded: 2,200 lb (998 kg)
Number of seats: 1

1957 MODEL B (PROJECT)

This project was designed to meet specifications made by the United States Air Force and the United States Navy. The end-product was to be a convertiplane with two rotors and having an aircraft-helicopter configuration. The change-over from one configuration to the other was to be effected simply by swivelling the wing, which had a four-bladed rotor at each tip. The blades, which were of small radius, were to rotate at high speed.

The power-plant planned for this project was two Boeing 502 turbines. A wing structure designed along the lines stated was given prolonged tests on the test bed.

1954 MODEL E (PROJECT)

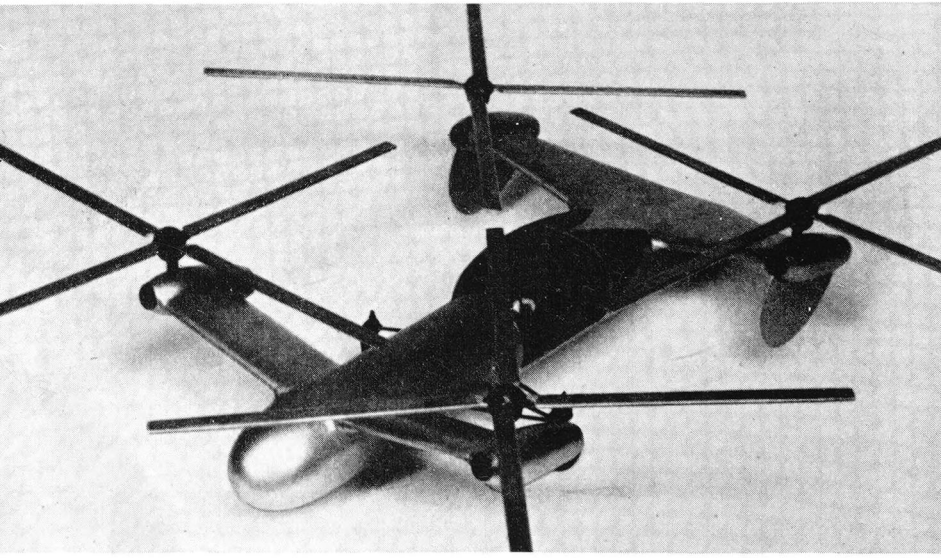
This project was for a large-sized rotorcraft with wings in tandem and

four four-bladed intermeshing rotors. Power was to be provided by four gas-turbines, and the market aimed at was freight or passenger carriage over short distances.

Engine: 4 gas-turbines, equivalent to 5,700 h.p.
Rotor diameter: 54 ft 8 in (16·66 m)
Weight unloaded: 30,500 lb (13,835 kg)
Weight fully loaded: 42,500 lb (19,278 kg)
Cruising speed: 140 m.p.h. (225 k.p.h.)
Inclined climb: 2,100 ft/min (640 m/min)
Range: 300 miles (483 km)
Number of seats: 70

1954 MODEL F (PROJECT)

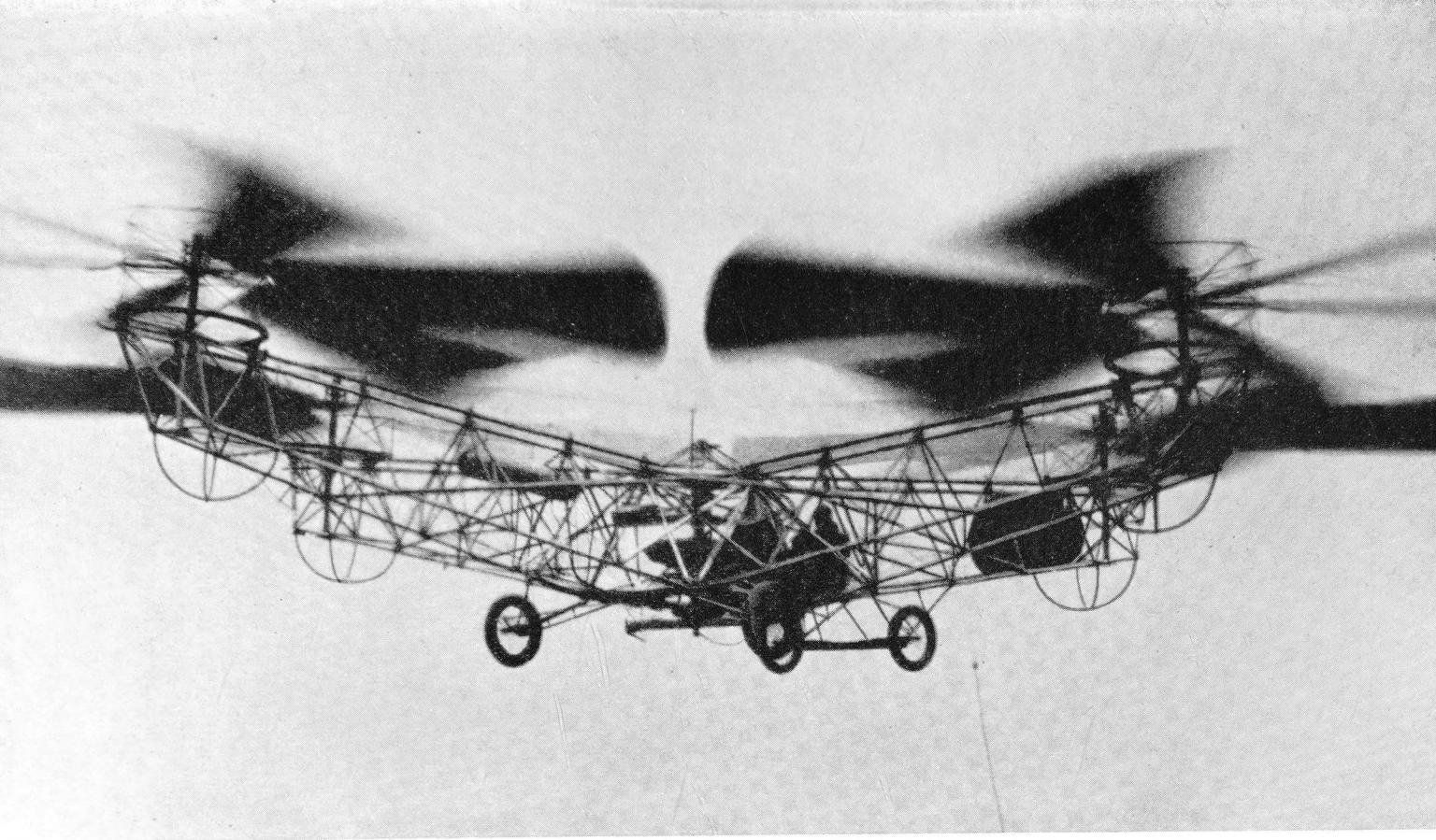
This project called for a single-seater helicopter of less ambitious proportions than Model E. It was to have four rotors with intermeshing blades and power provided by four French Artouste II shaft-turbine engines built under licence in the United States.



MODEL F

CURTISS-BLEECKER, 1931

At the time when the Autogiro Company of America had just come into being and autogyros seemed destined to provide a temporary solution to



DE BOTHEZAT 1922

the problem of vertical landing, an American engineer, M. B. Bleecker, was fascinated by the idea of a rotor driven by airscrews on the blades, as in the Hellesen-Kahn helicopter and the Isacco helicogyro. Bleecker's design differed from the others in that his airscrews did not have individual engines but were connected by gearing to a single central Pratt and Whitney 420 h.p. radial power unit.

As constructed by the Curtiss-Wright Corporation, this intricate aircraft looked rather like a merry-go-round of four small monoplanes. Each of the wing-shaped blades had auxiliary control surfaces which, when operated collectively, were to make the aircraft rise or descend, and when operated differentially, to ensure stability.

This helicopter successfully made a few 'hops' inside the hangar where it was built, but it was abandoned because of its lack of stability and the failure of attempts to eliminate vibration.

The landing gear consisted of three fixed wheels.

Engine: Pratt and Whitney, 420 h.p.
Rotor diameter: 47 ft 5 in (14·45 m)
Weight fully loaded: 3,306 lb (1,500 kg)
Number of seats: 2

DE BOTHEZAT

The first rotorcraft ordered by the United States Army was made by de Bothezat.

This Russian engineer who had emigrated to the United States started in July 1921 to build a helicopter at Dayton under the auspices of the United States Air Service.

The helicopter had four six-bladed rotors mounted at the ends of beams 65 feet $7\frac{3}{8}$ inches (20 metres) in length, forming a cross and intersecting in all directions. The rotor axes were not parallel but slightly inclined inwards so that if extended they would have met at a point directly above the centre of gravity. Besides the rotors with variable-pitch blades, the helicopter had two horizontal propellers called 'steering airscrews' as well as two small airscrews placed above the gearbox and acting as regulators for the 220 h.p. engine. Ready for flight, the helicopter weighed 3,550 pounds (1,610 kilos).

On 18 December 1922, during a test by the Technical Section at McCook Field (now known as Wright Field), the aircraft rose 6 feet (1·83 metres) from the ground and remained airborne for 1 minute 42 seconds.

On 19 January 1923 it lifted two persons to a height of 4 feet (1·22 metres), and on 17 April 1923 it lifted not only the pilot but also four people hanging to the framework.

Because of its great moment of inertia, the helicopter proved quite

stable, yet despite the series of sustained flights which it performed, the Air Corps rapidly lost interest in it.

Sometime between 1939 and 1940 a helicopter with contra-rotating rotors, 30 feet (9·14 metres) in diameter, was tested in tethered condition, but the project was dropped because the craft could not be easily controlled. A special feature of this model was that the engine, a Franklin 70 h.p., and the transmission were mounted between the rotors.

DE CHAPPEDELAINE

In 1945–6 the American Die and Tool Company sponsored the construction of a helicopter designed by a Frenchman, Jean de Chappedelaine.

This helicopter had a flow-controlled rotor, and the boundary layer flow was used to improve its lifting power.

1946 CHAPPEDELAINE

Automatic balance for this two-seater rotorcraft was to be provided by means of a floating rotor. De Chappedelaine's idea was that the air issuing from a supercharger should be directed to the rotor tips.

DE LACKNER

Donald de Lackner, part-designer of the pre-World War II QED Racer, initially designed a small two-seater helicopter with rotors in tandem, then, still in the rotary-wing field, went over to manufacturing the Helivector, a kind of flying motor-cycle designed by L. C. McCarthy.

1946 CLOUDUSTER

This helicopter had two two-bladed rotors in tandem and the engine situated at the end of the fuselage. The engine drove the forward rotor by means of a longitudinal shaft running through the whole length of the fuselage.

The latter was almost cylindrical in shape and consisted of a bodywork of tubes covered partly in fabric and partly in a light alloy.

Engine: Lycoming, 135 h.p.
Rotor diameter: 24 ft (7·32 m)
Weight fully loaded: 1,600 lb (726 kg)
Cruising speed: 85 m.p.h. (137 k.p.h.)
Number of seats: 2

1954 DH-4 HELIVECTOR

This single-seater amphibious helicopter was developed for de Lackner by L. C. McCarthy, formerly an engineer with the Glenn

Martin Company, on the basis of research work done by the NACA in 1953 and 1954.

Immediately after the first tests, the Helivector Corporation was formed to undertake the production of the DH-4, as a subsidiary of De Lackner Helicopters Inc.

This helicopter has two contra-rotating two-bladed rotors located immediately beneath the platform upon which the pilot stands. The pilot uses motor-cycle handlebars to control the outboard engine and also for yaw controls.

No special controls are provided for tilting the rotorcraft laterally and longitudinally; to do so, the pilot merely bends his body in the direction required.

Flotation pontoons are set on outriggers round a central pontoon placed just below the two rotors.

This version's first successful flight took place in January 1955.

There is also a military version, known as the Aerocycle. Its distinctive features are a more powerful Mercury engine and foldable outrigger arms.

Engine (civil): Mercury 20, 30 h.p.
(military): Mercury 55, 43 h.p.
Rotor diameter: 15 ft (4·57 m)
Weight fully loaded: 400 lb (181 kg)
Cruising speed: (max.) 75 m.p.h. (121 k.p.h.)
Absolute ceiling: 10,000 ft (3,048 m)
Range: 50 miles (80 km)
Number of seats: 1

1958 DH-5 AEROCYCLE

In this helicopter, developed from the DH-4, power from a Kiekhaefer outboard engine developing 40 h.p. and located on a small platform, drives the co-axial contra-rotating rotors through a belt.

Tail booms of various kinds with elevators at the ends have been fitted to this version.

The landing gear beneath the rotors consists of tubular skid landing.

The Aerocycle was tested at the Forrestal Research Centre.

DEL MAR

As part of their research into advanced weapons support systems, Del Mar Engineering Laboratories of Los Angeles have developed flying platforms in the form of tiny helicopters providing manned flight and cargo-carrying facilities to front line Army and Marine units. Collectively, these rotorcraft, which are available in one-man or drone versions, form a family known as 'Whirlymites'.

1960 DH-1A WHIRLYMITE SCOUT

This miniature helicopter, which first flew in June 1960, is a kind of basic aircraft to which various helicopter components can be added. The rotor consists of three bald blades and a highly simplified frame of tubes with a tail rotor at the end of a tubular beam. The pilot has a bucket seat. Power comes from an air-cooled 6-cylinder Kiekhaefer Mercury engine developing 80 h.p. derated to 65 h.p.

Replacing the pilot's bucket seat by radio controls transforms the DH-1A into the DH-1B, a tactical drone helicopter.

The DH-1C is a target drone for training anti-missile crews.

In the DH-1D Packer, a further drone version designed for troop supply, the standard landing gear is replaced by rigid struts.

The DH-1E Spotter is the DH-1C equipped with TV and infra-red sensors.

All these versions can also be equipped with an AiResearch Model shaft-turbine and are then designated DH-2.

The DH-2A Whirlymite Scout has an AiResearch GTP30-100 developing 100 s.h.p.; the DH-2C, an AiResearch GTP30-91 of 85 s.p.h.

Engine: Kiekhaefer Mercury, 80 h.p., derated to 65 h.p.
Length: (fuselage) 15 ft 7 in (4·75 m)
Height: 7 ft (2·13 m)
Rotor diameter: 16 ft (4·88 m)
Weight empty: 360 lb (163 kg)
Cruising speed: 55 m.p.h. (89 k.p.h.)
Inclined climb: 1,300 ft/min (396 m/min)
Service ceiling: 13,000 ft (3,962 m)
Range: 90 miles (145 km)
Number of seats: 1

1963 DHT-1

The Del Mar Engineering Laboratories have also developed a training device, the DHT-1, to which the piloted Whirlymite DH1A or 2A trainer can be linked through a simple mechanism. This enables helicopter pilots to be safely trained. Four of these devices were built under U.S. Army contract for evaluation and delivered during 1964.

1966 DHT-2

This improved version of the DHT-1 is similarly a ground-based helicopter pilot trainer. It is fitted with a shaft-turbine.

Engine: AiResearch GTP30-100, 100 s.h.p.
Length: (overall) 19 ft 3 in (5·87 m)
Height: (overall) 7 ft 7 in (2·31 m)
Rotor diameter: 16 ft (4·88 m)

Weight empty: 350 lb (159 kg)
Number of seats: 1

1966 DH-20

This training device has two three-bladed rotors in tandem and is thus known under the designation of Whirlymite Tandem. It is powered by two turbine engines.

Engines (2)*:* AiResearch GTP30-100, each of 100 s.h.p.
Length: (fuselage) 15 ft 2 in (4·62 m)
Height: 8 ft (2·44 m)
Rotor diameter: 16 ft (4·88 m)
Weight empty: 670 lb (304 kg)
Number of seats: 1

DOMAN

Doman Helicopters Inc. was founded in 1945 for the purpose of exploiting patents taken out by an engineer named Glidden S. Doman, who during World War II had worked with Sikorsky. The patents in question related to a new system for controlling and attaching helicopter blades. The blades are held on the hub as if nothing more than mere variable-pitch airscrew blades. As regards the inclination of the rotor-tip plane with respect to the fuselage, this is assured by gimbal-mounting the rotor hub and rotating it by means of a unique constant-velocity driving system. No blade-flapping hinges, drag hinges or hinge dampers are required and bearings subject to centrifugal loads with oscillating motion are reduced to a minimum.

The Doman rotor incorporates the speed-reduction gearing as an integral part of the rotor assembly. All moving parts are contained within a common housing which precludes damage from weather or foreign matter.

Doman first tested his rotor in 1947 on a Sikorsky R-6 which had been loaned to him by the U.S. Air Force.

1947 LZ-1A

This helicopter was a Sikorsky R-6 (lent by the U.S.A.F.) converted to a Doman rotor and control system. The rotor had four blades, and though their length was increased from 38 to 40 feet (11·58 to 12·19 metres), this resulted in improved hovering ability and, curiously enough, did not lower the top speed.

The first flights took place early in 1950 and it should be noted that during one experimental flight this rotorcraft flew for forty minutes without the pilot needing even to touch the cyclic pitch control.

Engine: Franklin O-405-9, 245 h.p.

Length: 33 ft 11 in (10·34 m)
Height: 11 ft (3·35 m)
Rotor diameter: 40 ft (12·19 m)
Weight empty: 1,920 lb (871 kg)
Weight fully loaded: 3,000 lb (1,361 kg)
Cruising speed: 85 m.p.h. (137 k.p.h.)
Inclined climb: 900 ft/min (274 m/min)
Range: 400 miles (644 km)
Number of seats: 2

LZ-1A

1951 LZ-4 (CW-40)

The LZ-4 is the engineer-produced and hand-built prototype of the LZ-5. Built specifically for research purposes, it was taken over by Curtiss-Wright, where it was given the designation of CW-40. The LZ-4's maiden flight took place in November 1950.

Engine: Lycoming SO-590-B, 400 h.p.
Length: 38 ft 1 in (11·61 m)
Height: 11 ft 2 in (3·4 m)
Rotor diameter: 48 ft (14·63 m)
Weight empty: 2,970 lb (1,347 kg)
Weight fully loaded: 4,770 lb (2,164 kg)
Cruising speed: 78 m.p.h. (126 k.p.h.)
Inclined climb: 800 ft/min (244 m/min)
Absolute ceiling: 16,000 ft (4,877 km)
Range: 210 miles (338 km)
Number of seats: 8

LZ-4

1953 LZ-5 (YH-31)

The measurements and layout of this production model very closely resemble those of the hand-made LZ-4. The 8-cylinder supercharged engine is placed beneath the pilot's compartment; the crankshaft is inclined at an angle of 32 degrees and drive engagement to the rotor is through a fluid coupling.

The front cabin is big enough to take two pilots; the main cabin has room for six passengers with luggage, or four stretchers or cargo over an area of 40 square feet (3·7 square metres).

This helicopter has been supplied to the U.S. Army, where its official designation is YH-31. In order to speed up output for this outlet, Doman decided in 1953 to grant Hiller a licence to manufacture the mechanical components of the military version, while Doman himself continues independently to produce the LZ-5 commercial version.

Engine: Lycoming 580-D, 400 h.p.
Length: 38 ft (11·58 m)
Width: (maximum cabin) 5 ft (1·52 m)
Height: 10 ft 3 in (3·12 m)
Rotor diameter: 48 ft (14·63 m)
Weight empty: 2,860 lb (1,297 kg)
Weight fully loaded: 5,200 lb (2,359 kg)
Cruising speed: 86 m.p.h. (138 k.p.h.)
max: 105 m.p.h. (169 k.p.h.)
Inclined climb: 1,300 ft/min (396 m/min)
Absolute ceiling: 18,000 ft (5,486 m)
Range: 245 miles (394 km)
Number of seats: 8

LZ-5 (YH-31)

1959 D-10B

The D-10B is a variant of the LZ-5 and fitted with a Lycoming IO-720 or a supercharged THIO-720 engine. For the manufacture of the airframes Doman approached the Italian firm of Aeronautica Sicula in Sicily.

ENSTROM

The Enstrom Corporation was set up in Michigan for the purpose of marketing a conventional helicopter at a competitive price. The first prototype, which first flew in 1960, has since been considerably modified. Twyford Motors Ltd. is the U.K. licensee for the F-28.

1960 F-28

The F-28, originally a two-seater prototype with a semi-articulated two-bladed rotor, now has three seats and a fully articulated three-bladed rotor system with feathering, lead lag and flapping hinges offset by 6 inches (15·2 centimetres) from the rotor-shaft centre-line. The early steel-tube structure later became an aluminium semi-monocoque tail boom.

Engine: Lycoming HIO-360-AIA, 180 h.p.
Length: 28 ft (8·53 m)
Width: 7 ft 4 in (2·24 m)
Height: 9 ft 1 in (2·77 m)

Rotor diameter: 32 ft (9·75 m)
Weight empty: 1,250 lb (567 kg)
Weight fully loaded: 1,950 lb (885 kg)
Cruising speed: 95–115 m.p.h. (153–185 k.p.h.)
Inclined climb: 1,335 ft/min (407 m/min)
Service ceiling: 14,500 ft (4,420 m)
Range: 235 miles (378 km)
Number of seats: 3

EXEL

George Exel designed the prototype of a traditional helicopter which made its first flights in 1948.

1948 EXEL

This helicopter was equipped with a three-bladed main rotor, an anti-torque tail rotor and a 4-cylinder engine.

There was also a tricycle landing gear with two wheels forward and one aft, half-way between the front wheels and the tail rotor.

Engine: 100 h.p.
Rotor diameter: 30 ft (9·14 m)
Weight empty: 950 lb (431 kg)
Weight fully loaded: 1,450 lb (658 kg)
Cruising speed: 75 m.p.h. (121 k.p.h.)
Number of seats: 2

FILPER RESEARCH

Filper Research, a division of the Filper Corporation, has developed a tandem-rotor helicopter, the Beta 200, with William E. Orr, whose experience in the field springs from employment on the management side of Lockheed, Fairchild and United Aircraft's United Technology Center.

The chief engineer is J. Ford Johnson who worked for fifteen years with the Lockheed-California Company.

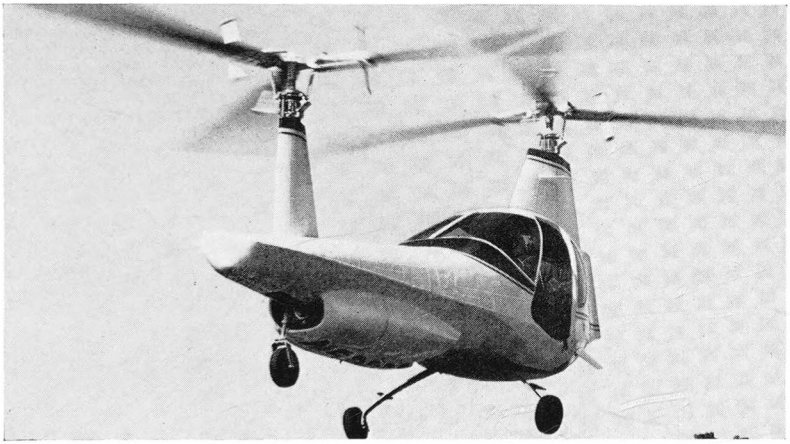
1965 BETA 200

The Beta 200, which made its maiden flight on 22 May 1966, is a small tandem-rotor helicopter of unorthodox appearance, using the newly-patented 'Gyroflex' rigid-rotor system. On each rotor blade, just outboard of the hub, there is a vertical rod with balance weights on each end.

The engine is mounted in front of the pilot's cabin, and housed in a cowling under the helicopter's long nose. Power is transmitted via a

transfer box and shafts running fore and aft. The rotor shafts are driven through right-angle gearboxes at the base of the rotor pylons.

Engine: Continental IO-360, 210 h.p.
Length: 19 ft (5·79 m)
Width: 7 ft (2·13 m)
Height: 11 ft 6 in (3·51 m)
Rotor diameter (2)*:* 20 ft 5 in (6·22 m)
Weight empty: 1,000 lb (454 kg)
Weight fully loaded: 1,700 lb (771 kg)
Cruising speed: 120 m.p.h. (193 k.p.h.)
max: 150 m.p.h. (241 k.p.h.)
Range: 400 miles (644 km)
Number of seats: 2–3



BETA 200

1966 BETA 300

This project is based on the main general lines of the 200 but with a retractable undercarriage. The 200's piston engine is replaced by an Allison turbine of the type used for LOH helicopters. The design embodies six seats, arranged in three pairs of two.

Engine: Allison 250-C18, 317 s.h.p.
Length: 22 ft 10 in (6·96 m)
Height: 12 ft (3·66 m)
Rotor diameter: 21 ft (6·4 m)
Weight: 1,102 lb (500 kg)
Cruising speed: 155 m.p.h. (250 k.p.h.)
Number of seats: 6

1967 BETA 400

This four-seater version of the Filper prototype has been flying since July 1967. It is powered with a Continental IO-520 engine of 250 h.p., and has a gross weight of 2,540 pounds (1,152 kilos).

FIRESTONE

The Firestone Tire and Rubber Company was incorporated in 1900 for the sale of the solid rubber tyres then in use. Shortly afterwards the company started to manufacture tyres itself and to grow parallel to the rapidly expanding motor-car industry.

During World War II the company extended its activities into the manufacture of synthetic rubber, tanks, trucks, aircraft wings, Bofors anti-aircraft guns, etc.

In 1943 Firestone absorbed G and A Aircraft of Pitcairn Field, Willow Grove, formerly known as the AGA Aviation Corporation, which in 1940 took over the Pitcairn Autogiro Company's contracts. These included the CG-4A, a troop-carrying glider, and the XO-61, a pusher-type autogyro. Between 1943 and 1945 the XR-9B, a dual-control helicopter, was designed, built and flight-tested by Firestone and the U.S. Army.

1942 XO-61

Built by Firestone's subsidiary, G and A, this was a two-seater, direct-take-off autogyro, with tricycle landing gear.

Engine: Jacobs R915, 300 h.p.
Rotor diameter: 48 ft (14·63 m)
Weight fully loaded: 3,000 lb (1,361 kg)

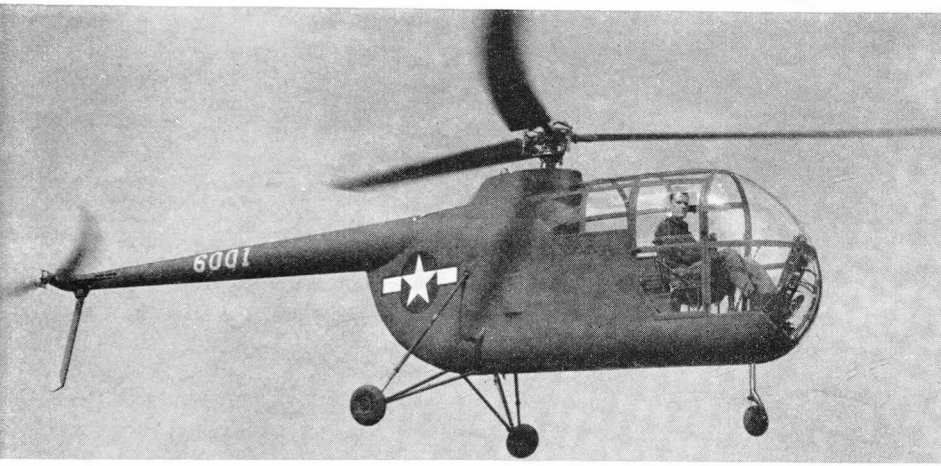
1944 XR-9B

Conceived in 1943, this small liaison helicopter was completed in 1944 with co-operation from the Army Air Force's Air Technical Service Command. The main rotor had three blades (and a fixed-type head); the tail rotor was 6 feet 6 inches (1·98 metres) in diameter. The prototype incorporated an experimental electro-hydraulic governor, which by acting on the simultaneous pitch control maintained a constant predetermined rotor speed, irrespective of the power used. With automatic assistance from this governor, the pilot could rise or descend vertically just by using his throttle.

The helicopter was made of welded steel tube covered with an alloy skin, while the tail boom had a balsawood core covered with alcad. For storage purposes this helicopter could be broken down into three parts: rotor blades, fuselage and boom assembly.

Engine: Lycoming O-290-5, 135 h.p.

Length: 27 ft 7 in (8·41 m)
Width: (at landing wheels) 9 ft (2·74 m)
Height: 8 ft 6½ in (2·61 m)
Rotor diameter: 28 ft (8·53 m)
Cruising speed: 80 m.p.h. (129 k.p.h.)
Weight fully loaded: 1,750 lb (794 kg)
Inclined climb: 1,000 ft/min (305 m/min)
Absolute ceiling: 10,000 ft (3,048 m)
Range: 250 miles (402 km)
Number of seats: 2



XR-9B

1945 GA-45

This helicopter was of the same lineage as the last, but with a roomier cabin which provided side-by-side seating.

1945 GA-50 (PROJECT)

The GA-50 was a project of about the same period as that of the GA-45. The GA-50 was designed to be a four-seater with dual tail rotors.

FLETTNER

In 1947 Anton Flettner, who both prior to and during World War II had been well known in German helicopter circles (see under Germany), left Bavaria and emigrated to the United States. There he was for some time attached as Consultant to the Office of Naval Research, then in 1949 he

founded the Flettner Aircraft Corporation in conjunction with C. E. Rosendahl, a former specialist in 'blimps' and dirigible airships.

GAZDA

Shortly before the end of World War II, Antoine Gazda, of Gazda Engineering, a firm well known in the armaments industry, produced the Helicospeeder, using a jet torque reaction.

Gazda also considered rotary-wing experiments on a DC-3 with a two-bladed rotor, which while auto-rotating would contribute to lift, and could also be retracted lengthwise into the fuselage. Gazda calculated that the additional weight in a B-36 from the 120-foot (36·6-metre) rotor required and the mechanism to lower it into the fuselage would be only 3,400 pounds (1,542 kilos).

1944 HELICOSPEEDER

In this helicopter, with its two-bladed mechanically-driven rotor, the conventional tail rotor was replaced by a jet exhaust system. Its piping had two extensions set horizontally and perpendicularly in respect of the fuselage, and they helped to reduce torque. In addition, the helicopter could be steered by varying the intensity of these lateral jets.

Engine: Gazda, 130 h.p.
Length: 19 ft (5·79 m)
Height: 8 ft 4 in (2·54 m)
Rotor diameter: 25 ft (7·62 m)
Weight fully loaded: 1,200 lb (544 kg)
Cruising speed: 140 m.p.h. (225 k.p.h.)
Number of seats: 2

GLATFELTER

Edward W. Glatfelter, a senior engineer with Boeing Vertol, was eager to investigate some new ideas for helicopter controls and drive systems, and in particular a completely new rotor system to suppress all flapping and dragging by means akin to a rigid rotor. He therefore built his own helicopter incorporating parts belonging to various others. His experimental model made its first hovering flights in June 1959. These were followed in this and later years by flights again aimed at studying the helicopter's behaviour when airborne.

1959 XRG-65

This single-seater is built up from several standard helicopter parts.

The main two-bladed rotor consists of parts of a Vertol HUP-2 rotor, the tail rotor hub is assembled from a Bell H-13, the pitch-bearing housings from a Sikorsky H-19, and commercial motor-vehicle spiral bevel gears are used for transmission.

This experimental helicopter's fuselage is of the steel tube type.

Engine: Continental A-65, 65 h.p.
Length: (fuselage) 19 ft (5·79 m)
Height: 6 ft 6 in (1·98 m)
Rotor diameter: 25 ft (7·62 m)
Weight empty: 600 lb (272 kg)
Weight fully loaded: 800 lb (363 kg)
Cruising speed: 65 m.p.h. (105 k.p.h.)
Ceiling: 5,000 ft (1,524 m)
Range: 40 miles (64 km)
Number of seats: 1

GLENVIEW

Since 1950 Glenview Metal Products has been engaged in the manufacture of industrial components, including parts for jet engines for power-guided missiles. The company's Aircraft Division includes Robert Mattox, who was formerly aircraft designer with the Pitcairn Aviation Corporation and works manager with Piasecki Helicopter Corporation. In 1954 Glenview revived a prototype helicopter designed by William E. Hunt, with Hunt himself as consulting engineer. Until it became a subsidiary of Glenview's, a firm known as Frontline Helicopter Corporation carried out the tests on this prototype. Glenview decided to replace the original with a more powerful engine.

1953 GMP-1 FLYRIDE

Since the cyclic control system is replaced by a fully tilting head, the rotor has no drag hinges.

The engine is in the aircraft's nose, which thus enables passengers or baggage to be placed near the centre of gravity. Instead of the five controls common to conventional aircraft, the Flyride has only two primary control units: a stick with a motor-cycle grip, and a throttle. The stick, which rests on an arm between the two seats, governs all movements on the horizontal plane: an accelerator of the type used in motor-vehicles controls upward and downward movement by means of a governor geared to the engine, and the pitch of the blades is regulated by the engine's output in terms of revolutions per minute.

Engine: Lycoming, 135 h.p.
Length: 35 ft 6 in (10·82 m)

Height: 8 ft 7 in (2·62 m)
Rotor diameter: 30 ft 6 in (9·3 m)
Weight empty: 1,150 lb (522 kg)
Weight fully loaded: 1,655 lb (751 kg)
Cruising speed: 90 m.p.h. (145 k.p.h.)
Inclined climb: 1,200 ft/min (366 m/min)
Absolute ceiling: 12,500 ft (3,810 m)
Range: 280 miles (451 km)
Number of seats: 2

GMP-1 FLYRIDE

GLUHAREFF

Eugene Gluhareff, a member of the same family as Michael and Serge Gluhareff at Sikorsky Aircraft, spent ten years as primary design and project engineer with that firm and then, still in the rotorcraft field, as designer of the XH-26 at the American Helicopter Company.

In 1952 he set up his own company to develop light jet engines and portable helicopters. Thus was born the pressure-jet engine G8-2, using liquid propane delivered under pressure and injected through the supersonic nozzle into the intake ducts, where its high exit velocity draws the outside air into the intake at a pre-determined 'fuel-air mixture' ratio.

1956 MEG-1X

This experimental strap-on-type helicopter consists of two cylinders, one for propane, one for compressed air, a single-bladed rotor with

counterweight and a fixed tail-surface attached to a central pylon structure.
Engine: G8-2
Weight empty: 60 lb (27 kg)
Weight fully loaded: 260 lb (118 kg)
Cruising speed: (max.) 55 m.p.h. (89 k.p.h.)
Number of seats: 1

1958 MEG-2X

Like its predecessor, this is of the strap-on type and differs from it only by having a two-bladed rotor and two G8-2 engines.
Engines (2)*:* G8-2
Rotor diameter: 20 ft (6·1 m)
Weight empty: 68 lb (31 kg)
Weight fully loaded: 290 lb (132 kg)
Cruising speed: 40 m.p.h. (64 k.p.h.)
Number of seats: 1

1958 MEG-3X

The same principles are used here as in the MEG-2X and the same two-bladed rotor, but it is now arranged as a flying platform with the pilot above the rotor.
Engines (2)*:* G8-2
Number of seats: 1

GOODYEAR

The Goodyear Aircraft Corporation is a subsidiary of the Goodyear Tire and Rubber Company, well known as manufacturers of tyres and lighter-than-air balloons such as Explorer I, with a capacity of 1,000,000 cubic feet (28,317 cubic metres) which exploded at a height of 60,000 feet (18,288 metres), and was followed by the helium-inflated Explorer II, which reached an altitude of about 72,395 feet (22,066 metres). In 1925 Goodyear also produced non-rigid airships.

In 1954 the company produced a single-seater helicopter intended for the tactical requirements of transporting one man only.

1954 GA-400R

This single-seater ultra-light helicopter, designed by Paul Ziegler, is powered by a water-cooled, two-cycle engine driving the rotors through a belt-and-pulley arrangement. The main rotor consists of two laminated blades balanced about the feather axes and mounted in a steel hub underslung from a teetering hinge. The airframe is constructed from welded tubing, and the landing gear is formed of parallel aluminium skids.

When used for training purposes the helicopter can be stabilized by the use of two persons, one supporting each side, until the trainee has acquired a thorough knowledge of the rotorcraft.

The first flight took place in 1954.

Engine: (outboard) Marine and MFG Big Twin, giving 31 h.p. at 5,000 r.p.m.
Length: 15 ft 10 in (4·83 m)
with rotor: 22 ft 2½ in (6·77 m)
Height: 7 ft 6 in (2·29 m)
Rotor diameter: 18 ft (5·49 m)
Weight empty: 235 lb (107 kg)
Weight fully loaded: 435 lb (197 kg)
Cruising speed: 46 m.p.h. (74 k.p.h.)
max: 69 m.p.h. (111 k.p.h.)
Inclined climb: 500 ft/min (152 m/min)
Absolute ceiling: 12,000 ft (3,658 m)
Range: 45 minutes (endurance)
Number of seats: 1

GRUDIEAIRE

An autogyro built by an enthusiast, Veldon Grudieaire, achieved such success that it led to the setting up in Arkansas of the firm Grudieaire Autogiros, which since 1954 has specialized in rotary-wing aircraft, producing propellers, rotor blades and autogyro kits.

1956 GH-4A

This rotary-wing glider has a welded airframe and a rotor made of wooden blades with the same airfoil shape from tip to tip.

As a rotor-fitted glider, this machine has a take-off speed of 20 m.p.h. (32 k.p.h.). A few minor modifications and the addition of a McCulloch engine and a propeller convert the glider into the GH-4 Gyroplane.

Length: 8 ft 2 in (2·49 m)
Rotor diameter: 21 ft (6·4 m)
Weight empty: 125 lb (57 kg)
Number of seats: 1

GYRODYNE

After the end of World War II, during which Peter J. Papadakos worked with various aircraft manufacturers, he brought together a group of engineers to produce a helicopter with a better performance than any of

those existing at the time. This group became the nucleus of the present Gyrodyne Company of America Incorporated (GCA).

In the early 1950s Gyrodyne settled on the co-axial configuration and concentrated its efforts on perfecting helicopters of this type. The invention of the rotor-tip brake control system for directional flight was the key to the successful development of GCA's co-axial helicopters.

It was planned that they should take off vertically and yet possess greater horizontal cruising speed and range than the traditional helicopter.

Encouraged by its first results, the company has done developmental work on other projects, including a large-scale rotorcraft designed to carry seventy passengers.

1949 GCA-2A

This is the Bendix 1947 Model J (*q.v.*) acquired by GCA and modified by adding on each side of the fuselage a 100 h.p. engine carried on an outrigger. These engines gave equal thrust and could operate independently.

The co-axial contra-rotating rotors worked continuously; in horizontal flight the cyclic pitch variation of the blades was obviously less than that required in a normal helicopter.

The tests of this rotorcraft were intended to provide basic data for the company's programme of developing compound aircraft.

The first flight took place at the end of November 1949.

Engines (3)*:* one Pratt and Whitney R-985, 450 h.p., and two Continental C85-12, 100 h.p. each
Length: 21 ft 3 in (6·48 m)
Height: 14 ft 3 in (4·34 m)
Rotor diameter: 48 ft (14·63 m)
Number of seats: 4–5

1952 GCA-2C

This version resembled its predecessor in some respects but differed in being a pure helicopter with two co-axial contra-rotating two-bladed rotors of semi-rigid type, and incorporating automatic locks which prevented flapping at low rotor speeds. The entire transmission system contained only five gears altogether.

The engine was situated just behind the rotor blade axle, and there were also twin fins and rudders.

It should be observed that a system of co-axial rotors working on the same principle was incorporated in the Gyrodyne Rotorcycle XRON-1.

Engine: Pratt and Whitney R-985, 450 h.p.
Length: (overall) 18 ft (5·49 m)
Height: 14 ft 4 in (4·37 m)
Rotor diameter: 48 ft (14·63 m)
Weight empty: 3,800 lb (1,724 kg)

Weight fully loaded: 5,400 lb (2·449 kg)
Cruising speed: 89 m.p.h. (143 k.p.h.)
max: 110 m.p.h. (177 k.p.h.)
Inclined climb: 1,460 ft/min (445 m/min)
Absolute ceiling: 22,100 ft (6,736 m)
Range: 270 miles (435 km)
Number of seats: 6

1951 GCA-3 HELIDYNE (PROJECT)

This project for a convertiplane was to have two co-axial contra-rotating rotors, and on each side of the fuselage a stub wing with an outboard engine and airscrew. During horizontal flight these engines would provide forward propulsion. The Helidyne thus combined the features of a helicopter and a twin-engined fixed-wing aircraft.

Engines (2)*:* Pratt and Whitney R-1340, giving 1,200 h.p. in all
Length: 31 ft 10 in (9·7 m)
Height: 16 ft 9 in (5·11 m)
Rotor diameter: 62 ft (18·9 m)
Weight empty: 7,800 lb (3,538 kg)
Weight fully loaded: 11,000 lb (4,990 kg)
Cruising speed: 125 m.p.h. (201 k.p.h.)
Inclined climb: 1,090 ft/min (332 m/min)
Absolute ceiling: 18,900 ft (5,760 m)
Range: 294 miles (473 km)
Number of seats: 18

1949 GCA-5 (PROJECT)

This project differed from others made by the same company in that it called for a single rotor instead of the usual two co-axial rotors. The single rotor was to have four blades rigidly attached to a universal mounted hub, so that the general configuration was that of one main and one anti-torque rotor. The tail rotor, however, was to be movable so that in translational flight it could tilt and take up the position of an airscrew. Normally, the tail rotor absorbed 80 per cent of the available power, and only the remaining 20 per cent was left over for the main rotor. When the tail rotor was swung aft, with a simultaneous increase in pitch, the pitch of the main rotor was decreased and it thus absorbed even less power.

Engine: 274 h.p.
Rotor diameter: 36 ft (10·97 m)
Weight empty: 2,035 lb (923 kg)
Weight fully loaded: 2,795 lb (1,268 kg)
Cruising speed: 155 m.p.h. (249 k.p.h.)
Range: 264 miles (425 km)
Number of seats: 3

1949 GCA-7 (PROJECT)

This project was designed to change the machine from a helicopter into a fixed-wing aircraft with gradual increase in forward speed. On each side of a wide fuselage a stub wing carried an engine driving pusher propellers. The latter could be declutched for take-off and for landing, i.e. when the aircraft was used as a helicopter.

The GCA-7 was to be amphibious. The entire lower structure and also the wings were to be sealed and waterproofed so that landings could be made on water without floats.

Engines (2)*:* Lycoming GSO-580, 375 h.p.
Width: (stub wing) 26 ft (7·92 m)
Rotor diameter: 52 ft (15·85 m)
Weight empty: 4,646 lb (2,107 kg)
Weight fully loaded: 7,600 lb (3,447 kg)
Cruising speed: 150 m.p.h. (241 k.p.h.)
Inclined climb: 1,300 ft/min (396 m/min)
Absolute ceiling: 8,800 ft (2,682 m)
Range: 250 miles (402 km)
Number of seats: 12 (2 crew, 10 passengers)

1949 GCA-8 GYROLINER (PROJECT)

This was to be a scaled-up version of the Helidyne and large enough to carry as many passengers as a good-sized transport aircraft. The engines were to be placed on stub wings and be fitted with propellers.

Rotor diameter: 90 ft (27·43 m)
Weight empty: 27,000 lb (12,247 kg)
Weight fully loaded: 40,000 lb (18,144 kg)
Cruising speed: 280 m.p.h. (451 k.p.h.)
Number of seats: 56 (2 pilots, 54 passengers)

1949 GCA-9 (PROJECT)

This project for a 'Helidyne Transport' with co-axial configuration was to be developed more especially as a rotorcraft for use in feeder line service.

Engines (2)*:* 600 h.p.
Rotor diameter: 62 ft (18·9 m)
Weight empty: 7,800 lb (3,538 kg)
Weight fully loaded: 13,000 lb (5,897 kg)
Cruising speed: 160 m.p.h. (257 k.p.h.)
Number of seats: 18 (1 pilot, 17 passengers)

1951 GCA-21 (PROJECT)

This project for a freight rotorcraft was to have the company's usual co-axial configuration, and to be powered by a turboprop engine.

Engine: Allison turboprop equivalent to 5,000 s.h.p.

Rotor diameter: 100 ft (30·48 m)
Weight empty: 18,000 lb (8,165 kg)
Weight fully loaded: 52,500 lb (23,814 kg)
Cruising speed: 75 m.p.h. (121 k.p.h.)
Range: 65 miles (105 km)

1955 GCA-24 (PROJECT)

This was a project for a cargo helicopter or flying crane, designed to carry a cargo pack.

The design embodied as before two co-axial contra-rotating two-bladed rotors shaft-driven by gas-turbine engines.

Engines (2)*:* turboprop, equivalent to 3,500 s.h.p. each
Rotor diameter: 110 ft (33·53 m)
Weight empty: 21,630 lb (9,812 kg)
Weight fully loaded: 70,000 lb (31,751 kg)
Cruising speed: 90 m.p.h. (145 k.p.h.)
Inclined climb: 1,000 ft/min (305 m/min)
Number of seats: 3

1954 GCA-32 (PROJECT)

This project for a convertiplane followed the company's usual configuration of two co-axial contra-rotating four-bladed rotors, together with stub wings and airscrews.

Engines (2)*:* Wright, 800 h.p.
Rotor diameter: 60 ft (18·29 m)
Weight fully loaded: 14,000 lb (6,350 kg)
Cruising speed: 160 m.p.h. (257 k.p.h.)
Absolute ceiling: 18,500 ft (5,639 m)
Range: 140 miles (225 km)
Number of seats: 7

1955 GCA-33 (PROJECT)

This project called for two two-bladed co-axial contra-rotating rotors powered by a single engine.

Engine: Lycoming, 150 h.p.
Rotor diameter: 28 ft (8·53 m)
Weight fully loaded: 1,600 lb (726 kg)
Cruising speed: 75 m.p.h. (121 k.p.h.)
Absolute ceiling: 14,500 ft (4,420 m)
Range: 120 miles (193 km)
Number of seats: 2

1954 GCA-35 GYROLINER (PROJECT)

The design of this high-speed convertiplane called for a power source

consisting of two turboprop engines, as in the GCA-24. It was to have wings and airscrews on either side and the rotary wing was to have two co-axial contra-rotating two-bladed rotors.

Engines (2)*:* turboprop, equivalent to 7,000 s.h.p. each
Rotor diameter: 88 ft (26·82 m)
Weight fully loaded: 77,000 lb (34,927 kg)
Cruising speed: 230 m.p.h. (370 k.p.h.)
Inclined climb: 2,350 ft/min (716 m/min)
Range: 500 miles (805 km)
Number of seats: 70

1956 GCA-41 (XRON-1 ROTORCYCLE)

This portable single-seater helicopter with two co-axial contra-rotating two-bladed rotors, developed for the United States Navy, had its first trials in 1956.

The Rotorcycle, which benefited from the progressive development of the special rotor system in the same company's Model 2C, was originally meant to be fitted with a 44 h.p. Nelson engine. This was later replaced by a 62 h.p. Porsche engine. Another version has also been tried with a Solar YG-62 Titan shaft-turbine. The Rotorcycle can be folded up into a small package for transport purposes.

Engine: Porsche GP-702-1, 62 h.p.
Length: 11 ft 6½ in (3·52 m)
Height: 8 ft (2·44 m)
Rotor diameter: 17 ft (5·18 m)

XRON-1 ROTORCYCLE

Weight unloaded: 425 lb (193 kg)
Weight fully loaded: 690 lb (313 kg)
Cruising speed: 45 knots (83 k.p.h.)
Inclined climb: 600 ft/min (183 m/min)
Service ceiling: 6,500 ft (1,981 m)
Range: 51 nautical miles (94 km)
Number of seats: 1

1959 GCA-59 (YRON-1 ROTORCYCLE)

Of the same type as its predecessor, this Rotorcycle, for which the U.S. Navy designation is YRON-1, has a rotor with a slightly larger diameter and is fitted with an engine specially developed by the firm of Porsche of Stuttgart in Germany. This version was evaluated at the U.S. Naval Air Test Centre, Patuxent River, Maryland, and later by the U.S. Marine Corps.

Engine: Porsche YO-95-6, 72 h.p.
Height: 9 ft (2·74 m)
Rotor diameter: 20 ft (6·1 m)
Weight unloaded: 550 lb (249 kg)
Weight fully loaded: 832 lb (377 kg)

YRON-1 ROTORCYCLE

Maximum speed: 78 m.p.h. (126 k.p.h.)
Service ceiling: 11,188 ft (3,410 m)
Range: 56 miles (90 km)
Number of seats: 1

1959 DSN-1, QH-50A

The DSN-1, formerly known as the QH-50A, was based upon the results of the various tests and evaluation programmes conducted on the Rotorcycle. The basic Rotorcycle frame was chosen by the Bureau of Naval weapons for development of the DASH (drone anti-submarine helicopter).

This pilotless developmental prototype is controlled from a destroyer. It has the same airframe, rotor, and engine as the YRON-1. In 1961 it was tested from the U.S.S. *Hazlewood.*

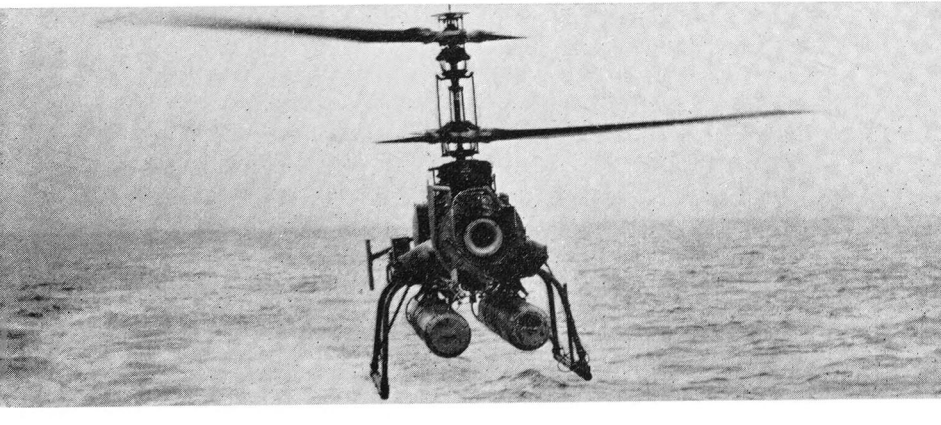
1960 DSN-2, QH-50B

This interim development model for DASH, now the QH-50B instead of the DSN-2 as formerly, is equipped with twin Porsche engines.

1962 DSN-3, QH-50C

This mass-produced drone (of which QH-50C is the later designation) is fitted with a turbine engine and co-axial laminated wood rotors. It is armed with torpedoes and is used mainly on anti-submarine duties. It is guided by radio and tracked by radar.

Engine: Turboshaft Boeing T50-BO-8A, 300 s.h.p.
Length: (overall) 12 ft 11 in (3·94 m)
Width: (overall) 5 ft 3 in (1·6 m)
Height: (overall) 9 ft 8½ in (2·96 m)



QH-50C

Rotor diameter: 20 ft (6·1 m)
Weight empty: 1,114 lb (505 kg)
Weight fully loaded: 2,275 lb (1,032 kg)
Cruising speed: 60 m.p.h. (97 k.p.h.)
max: 92 m.p.h. (148 k.p.h.)
Rate of climb: 1,880 ft/min (573 m/min)
Service ceiling: 16,400 ft (4,999 m)

1964 QH-50D

This drone, part of the DASH programme, follows the same general lines as its predecessors but has both a larger turbine and co-axial fibre-glass rotors.

Engine: Turboshaft Boeing T50-BO-12
Rotor diameter: 20 ft (6·1 m)
Weight empty: 1,035 lb (469 kg)
Weight fully loaded: 2,330 lb (1,057 kg)
Cruising speed: 63 m.p.h. (101 k.p.h.)
Rate of climb: 2,800 ft/min (853 m/min)
Service ceiling: 18,000 ft (5,486 m)

HAIG

The Haig K Aircraft Corporation was set up for the development of a test bed to study an improved rotor and control system.

1959 HK-1

This helicopter was provided with a three-bladed rotor driven by a flat 4-cylinder air-cooled engine placed in front of the pilot. The under-carriage is of the tricycle type.

Engine: Continental, 85 h.p.
Rotor diameter: 26 ft 4 in (8·03 m)
Weight empty: 610 lb (277 kg)
Weight fully loaded: 1,020 lb (463 kg)
Number of seats: 2

HELICOM

Helicom Inc., first known under the name of Helicopter Research Company, has developed an ultra-light single-seat conventional helicopter intended to be built by amateurs who purchase either plans or kits of parts. Earlier, about 1950, Emigh, the founder of Helicopter Research Company, had produced the light plane known as the Trojan.

1960 COMMUTER JUNIOR

This helicopter was the outcome of study and trials carried out over several years before its maiden flight in the summer of 1960. The Commuter Junior is a helicopter with a rotor consisting of two metallic blades and a fuselage of steel tube structure.

The engine is set vertically to simplify driving the rotor. Various engines have been fitted on this model from the Continental C75 to the Continental C90.

Engine: Continental C90-12F, 90 h.p.
Length: (overall) 23 ft 6 in (7·16 m)
Height: 7 ft 10 in (2·39 m)
Rotor diameter: 21 ft (6·4 m)
Weight empty: 639 lb (290 kg)
Weight fully loaded: 948 lb (430 kg)
Cruising speed: (max.) 75 m.p.h. (121 k.p.h.)
Inclined climb: 1,200 ft min (366 m/min)
Service ceiling: 10,500 ft (3,200 m)
Range: 150 miles (241 km)
Number of seats: 1

HELICOPTER ENGINEERING AND CONSTRUCTION

After a period of employment with Sikorsky, Harold E. Lemont formed his own company, the Helicopter Engineering and Construction Corporation.

The rotorcraft which he designed carried simplification in manufacture to the limit by the utmost possible use of ready-made motor-vehicle parts, and in control by embodying all controls into a wheel mounted on a stick.

1946 MODEL 100

This single-seater helicopter had a conventional three-bladed wooden rotor and a control column of the hanging-stick type with a governor to control the engine revolutions. The fuselage was built from tubular steel mainly covered with plywood, though its aft portion was fabric-covered. There was a four-wheel landing gear.

Ground tests were started in 1947.

Engine: Continental, 75 h.p.
Rotor diameter: 18 ft 6 in (5·64 m)
Weight empty: 350 lb (159 kg)
Weight fully loaded: 700 lb (318 kg)
Cruising speed: 100 m.p.h. (161 k.p.h.)
Inclined climb: 1,200 ft/min (366 m/min)
Number of seats: 1

HERRICK

In 1931 Gerard P. Herrick, with assistance from Ralph Herbert McClarren of the Franklin Institute, experimented with the novel idea of constructing a biplane with a rotary wing by arranging the upper wing in such a way that it could be either rotated round a vertical axle, or immobilized in its usual position.

The aircraft would thus take off as a biplane, and when it was airborne the pilot could release the upper wing. The latter would then start to rotate and would act as a two-bladed rotor, similar to that in an autogyro. This would enable the aircraft to make steep descent landings.

1931 HV-1

This was a biplane in which the upper wing could act as a two-bladed rotor. The two blades were rigidly connected to the hub by a single flapping hinge. It is obvious that, since this rotor when immobilized also acted as a wing parallel to the lower wing, it had a good aerodynamic design.

Herrick's 'vertaplane' was finished towards the end of 1931, and it first made a few short hops to test the control system.

During a flight at a height of 4,000 feet (1,220 metres) the pilot tried to release the rotor, but the aircraft went out of control and crashed.

Engine: Poyer 3-cylinder, 48 h.p.
Length: 17 ft (5·18 m)
Width: (span) 30 ft (9·14 m)
Height: 8 ft (2·44 m)
Weight fully loaded: 850 lb (386 kg)
Number of seats: 1

1937 HV-2A

On 30 July 1937 this aircraft, based on the same principle as the HV-1, took off as a fixed-wing aircraft, and then at a height of 1,700 feet (518 metres) was successfully transformed into a rotary-wing aircraft which landed as an autogyro.

Engine: Kinner B-5, 125 h.p.
Width: (fixed-wing span) 28 ft (8·53 m)
Lower wing area: 100 ft² (9·29 m²)
Rotor diameter: 24 ft (7·32 m)
Blade area: 70 ft² (6·5 m²)
Weight fully loaded: 1,700 lb (771 kg)
Cruising speed: (max.) 100 m.p.h. (161 k.p.h.)
Number of seats: 1

1949 HC-6 (PROJECT)

After World War II Herrick designed a convertiplane, a small-scale

model of which was tested in a wind tunnel. Its configuration was similar to that of its predecessors, but there was one appreciable difference: provision was made for flight as a helicopter by fitting a ram-jet engine at each tip of the rotor, and the lower wing was of the 'sesquiplane' type, i.e. appreciably shorter than the upper or rotor wing. The latter remained fixed in horizontal flight, but was released for auto-rotational flight, as required.

Engine: 300 h.p. plus ram-jets, giving 260-lb thrust
Weight empty: 2,490 lb (1,129 kg)
Weight fully loaded: 3,450 lb (1,565 kg)
Cruising speed: (max.) 250 m.p.h. (402 k.p.h.)
Number of seats: 1

HIGGINS

In 1942 an Aircraft Division was formed in Higgins Industries Inc., owned by Andrew Higgins, with the object of manufacturing transport aircraft for the United States Air Force.

There was also a Helicopter Division concerned with building and perfecting a helicopter designed by Enea Bossi.

1943 EB-1

This small two-seater helicopter had a main four-bladed rotor, consisting of two two-bladed rotors a few inches apart, and a small two-bladed tail rotor. The latter was fixed to the end of the upward-rising tail so that the tail rotor hub was at approximately the same level as the main rotor.

The cabin interior was designed to resemble as closely as possible that of a lightweight aircraft with a wheel control column and a standard panel of flying instruments.

Engine: Warner, 190 h.p.
Rotor diameter: 32 ft (9·75 m)
Weight empty: 1,950 lb (885 kg)
Weight fully loaded: 2,550 lb (1,157 kg)
Cruising speed: (max.) 125 m.p.h. (201 k.p.h.)
Number of seats: 2

HILL-KEMMAN

Keith Hill and Roger Kemman have designed and produced a light helicopter of the utmost simplicity so that it can, when required, be built by an amateur.

1959 HK-1

This single-seater consists of a simple tubular structure to carry a 40 h.p. Mercury engine driving a two-bladed rotor. The controls have been simplified in the extreme by means of a hydraulic system which can tilt the entire transmission shaft.

HILLER

In 1942, as soon as he had finished his studies, Stanley Hiller Jr. founded the Hiller Aircraft Company in California. Two years later, during 1944, a first helicopter using the co-axial configuration was ready to fly.

Later, in partnership with the Kaiser Corporation, a two-seater co-axial helicopter, the X-235, was built under a United States Navy contract. But this rotorcraft was abandoned at the end of 1945 at the very time it was to undergo trials.

Hiller parted company with Kaiser, took up his co-axial patents and formed United Helicopters Inc., which developed the Commuter, still to the co-axial formula. Simultaneously, the J5, the first jet torque-compensating helicopter in the United States, was built.

At this point Hiller threw over the co-axial configuration in favour of a single main rotor. He also launched a new control system to be embodied in all Hiller's later helicopter output and known as Rotomatic, signifying that through the control stick the pilot actually moves the control rotors or paddles which, in their turn, aerodynamically operate the main rotor blades. Thus, if the main rotor moves out of equilibrium, it drags the servo-rotor with it, with a resultant change of pitch and reaction which automatically brings the main rotor back to its original position.

In 1955 Gerhard Sissingh joined Hiller's staff. Sissingh is one of Germany's leading rotary-wing experts. He had previously worked with the Flettner aircraft group and during World War II was head of helicopter research at the AVA, the Reich Aerodynamic Research Institute, at Göttingen. For some time after the war he had worked as a research scientist at the Royal Aircraft Establishment, Farnborough, England.

Apart from its large-scale production of numerous models, United Helicopters also perfected a helicopter powered by ram-jets, and an experimental flying platform, which is a ducted propeller platform.

Since 1954, under a contract with the United States Air Force's Air Research and Development Command, Hiller has also been working on various VTOL projects such as retractable rotors, tilting rotors, tilting wings, etc.

By the end of 1958 Hiller had marketed more than 1,000 helicopters.

In November 1960 United Helicopters merged with the Electric Autolite Corporation of Toledo, Ohio as Hiller Helicopters; in May 1964

the Fairchild Stratos Corporation acquired Hiller Helicopters from Electric Autolite as a wholly-owned subsidiary.

1944 X-235

This streamlined helicopter had a 235 h.p. engine and Hiller contra-rotating co-axial rotors. Built under a contract from the United States Navy by the Hiller-Kaiser partnership, it was abandoned before the hovering test stage was reached. This was the last co-operative effort between Hiller and the Kaiser Corporation.

1944 XH-44

First prototype of a helicopter produced entirely by Hiller, the XH-44 had a fuselage made of steel tubes covered with fabric, and contra-rotating co-axial rotors. The original version is now preserved at the Smithsonian Institution.

Engine: Lycoming, 150 h.p.
Rotor diameter: 25 ft (7·62 m)
Weight empty: 1,200 lb (544 kg)
Weight fully loaded: 1,600 lb (726 kg)
Cruising speed: 70 m.p.h. (113 k.p.h.)
Absolute ceiling: 8,000 ft (2,438 m)
Range: 130 miles (209 km)
Number of seats: 2

1946 UH-4 COMMUTER

This was a development of the XH-44, of which it retained the co-axial

XH-44

contra-rotating two-bladed rotors, though the latter's diameter was considerably increased.

Engine: Lycoming O-290-C, 150 h.p.
Rotor diameter: 33 ft (10·06 m)
Cruising speed: 75 m.p.h. (121 k.p.h.)
Inclined climb: 950 ft/min (290 m/min)
Absolute ceiling: 12,000 ft (3,658 m)
Range: 200 miles (322 km)
Number of seats: 2

1946 J5

To counteract torque this two-bladed-rotor experimental helicopter used not a conventional tail rotor but a jet-thrust system. The latter consisted of a fan blower placed just behind the engine with a 'stove pipe' tail forward. Air was thus forced under pressure through the hollow fuselage into a tail orifice where vanes directed the jet thrust laterally.

Main-rotor torque was effectively overcome, but this torque-compensation system's power requirements proved markedly excessive at speeds greater than 40 m.p.h. (64 k.p.h.)

1946 UH-5

The UH-5 saw the abandonment of the co-axial configuration in favour of the single rotor with a tail rotor. The prototype proved so unstable during its trials in November 1946 that its frame was tested with a new stability system later patented as the Hiller 'Rotormatic'.

1946 MODEL 360 UH-12 (UH-12A, H-23A, HTE-1)

The 360 resulted from the UH-5 test frame, which had proved markedly unstable. These defects were overcome by fitting the two-bladed rotor with two small perpendicular paddles which acted as a control rotor and were also connected to a hanging stick. There thus came into being the 'Rotormatic control' found on all subsequent Hiller productions. This servo 'paddle control' system tilts the rotor head and actuates the cyclic pitch control.

The 360's first flight goes back as far as 1947, and the utility version, the UH-12, was certificated in 1948. Because of its ease of handling, it has been used under every sort of climatic conditions, for night operations, as aerosol equipment for crop spraying, as an ambulance, etc.

The improved 1950 Model UH-12A had various service designations. In the United States Army it was H-23A, in use since December 1950 for evacuation purposes. The United States Navy HTE-1 was a trainer version of the 360.

Engine: Franklin 6V4-178-B33, 178 h.p.
Rotor diameter: 35 ft (10·67 m)

Weight fully loaded: 2,100 lb (953 kg)
Cruising speed: 75 m.p.h. (121 k.p.h.)
Inclined climb: 1,000 ft/min (305 m/min)
Absolute ceiling: 12,700 ft (3,871 m)
Range: 130 miles (209 km)
Number of seats: 3

MODEL 360

1951 UH-12B (H-23B, HTE-2)

The United States Army and Navy gave the respective designations of H-23B and HTE-2 to the military development of Model 360, which in its original form had been shown in the Korean war to be under-powered.

The later development thus had a more powerful fan-cooled engine, mounted with the vertical crankshaft. Other refinements not found in the Model 360 included a head with an improved collective-balance weight system, a device consisting of two spring weights to eliminate vibration in the cyclic control system, and the replacement of the hanging stick to operate cyclic pitch by the customary floor-mounted column.

Of the two variants, the H-23B, a training or casualty transport helicopter, could carry two folding stretchers, one on each side of the cabin. The HTE-2, the United States Navy's standard trainer, had a four-wheeled undercarriage instead of the H-23B's skid-type landing gear.

Yet another variant, the UH-12B, the civil aviation version of the H-23B, came on to the market only when military requirements had been met. Apart from certain purely military fitments, the all-metal semi-monocoque UH-12B was identical with the H-23B.

Engine: Franklin 6V4-200-C33, 200 h.p.
Length: 38 ft 7 in (11·76 m)

Width: 5 ft (1·52 m)
Height: 9 ft 8 in (2·95 m)
Rotor diameter: 35 ft (10·67 m)
Weight empty: 1,656 lb (751 kg)
Weight fully loaded: 2,500 lb (1,134 kg)
Cruising speed: 70 m.p.h. (113 k.p.h.)
max: 84 m.p.h. (135 k.p.h.)
Inclined climb: 770 ft/min (235 m/min)
Absolute ceiling: 9,400 ft (2,865 m)
Range: 135 miles (217 km)
Number of seats: 3

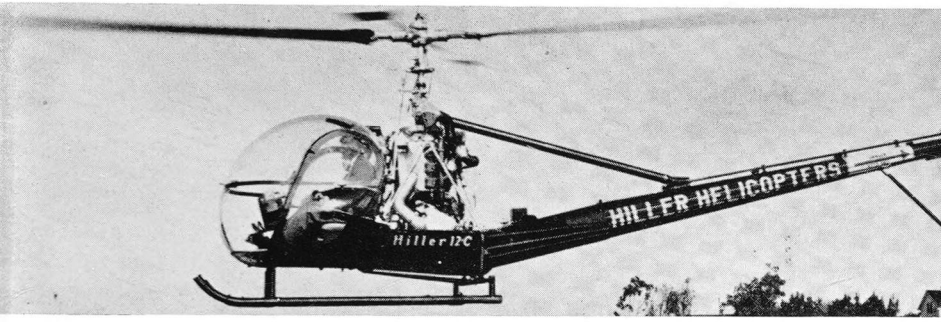
UH-12B

1954 UH-12C (H-23C)

This helicopter followed the same general lines as the UH-12B, but its wider canopy could easily accommodate three people side-by-side, with a useful load of 858 pounds (389 kilos) and a payload of 564 pounds (256 kilos).

The United States Army designation was H-23C, later OH-23C.
Engine: Franklin 6V4-200-C33, 200 h.p.
Rotor diameter: 35 ft (10·67 m)
Weight empty: 1,642 lb (745 kg)
Weight fully loaded: 2,006 lb (910 kg)

Cruising speed: 71 m.p.h. (114 k.p.h.)
max: 84 m.p.h. (135 k.p.h.)
Inclined climb: 770 ft/min (235 m/min)
Range: 138 miles (222 km)
Number of seats: 3



UH-12C

1957 UH-12D (H-23D) RAVEN

This helicopter is a marked improvement upon the 12C because of the fact that it was designed to operate for periods of 1,000 hours before needing any overhauls. Furthermore, it has a more powerful engine than its predecessors and an entirely new transmission system.

Its designation in the United States Army was H-23D, later OH-23D.
Engine: Lycoming VO-435-A1C, 250 h.p.
Length: (fuselage) 27 ft 8 in (8·43 m)
Height: 9 ft 8 in (2·95 m)
Rotor diameter: 35 ft 5 in (10·79 m)
Weight empty: 1,773 lb (804 kg)
Weight fully loaded: 2,700 lb (1,225 kg)
Cruising speed: 82 m.p.h. (132 k.p.h.)
max: 95 m.p.h. (153 k.p.h.)
Inclined climb: 1,050 ft/min (320 m/min)
Service ceiling: 13,200 ft (4,023 m)
Range: 197 miles (317 km)
Number of seats: 3

1958 UH-12E (OH-23G) RAVEN

This is a 305 h.p. version of the Raven of which it retains the basic frame. It can carry 65 per cent more payload than the 12C.

When United Helicopters became Hiller Helicopters, the UH designation was dropped.

On 18 May 1960 a Hiller 12E landed and took off at a point 18,000 feet (5,486 metres) up on Mount McKinley, Alaska.

The military designation of this all-purpose utility helicopter, originally H-23G, is now OH-23G. One of its first tasks with the United States Army was specialization in missile recovery duties at the White Sands Proving Ground.

The designation in the Canadian Army is CH-112.

Engine: Lycoming VO-540-C2B, 305 h.p.
Length: 26 ft 8 in (8·13 m)
Width: 10 ft (3·05 m)
Height: 10 ft 2 in (3·1 m)
Rotor diameter: 35 ft 5 in (10·79 m)
Weight empty: 1,700 lb (771 kg)
Weight fully loaded: 2,750 lb (1,247 kg)
Cruising speed: 87 m.p.h. (140 k.p.h.)
max: 95 m.p.h. (153 k.p.h.)
Inclined climb: 1,290 ft/min (393 m/min)
Service ceiling: 15,500 ft (4,724 m)
Range: 225 miles (362 km)
Number of seats: 3

1960 E4 (OH-23F) RAVEN

This is a four-seater version of the Model 12E. It is equipped with the same engine, the power of which, as in the 12E, can be increased by means of kits comprising dual carburettors and high-compression pistons. The cabin is longer than in the 12E and the payload somewhat less, because of a slight increase in the fuselage weight.

The E4 has an inverted V-stabilizer at the tail.

The military version, once known as the H-23F, is now the OH-23F.

Engine: Lycoming VO-540-C2B, 305 h.p.
Length: 29 ft 8 in (9·04 m)
Width: 10 ft (3·05 m)
Height: 10 ft 2 in (3·1 m)
Rotor diameter: 35 ft 5 in (10·79 m)
Weight empty: 1,777 lb (806 kg)
Weight fully loaded: 2,750 lb (1,247 kg)
Cruising speed: 87 m.p.h. (140 k.p.h.)
max: 95 m.p.h. (153 k.p.h.)
Inclined climb: 1,290 ft/min (393 m/min)
Service ceiling: 15,500 ft (4,724 m)
Range: 225 miles (362 km)
Number of seats: 4

1963 L3

The L3 resembles the 12E in having the same airframe and the same power-plant. It differs in having an SAS rotor with the system known as the Hiller 'L' rotor.

The so-called Stability Augmentation System (SAS) developed by the Hamilton Standard Division of the United Aircraft Corporation uses inertial sensors and electronic compensation. In practice a two-axis gyro-controlled SAS provides automatic stabilization about the pitch and roll axes. The blades of the rotor used here are of slightly greater chord than those of the standard Hiller Rotormatic.

Conversion kits are available to transform the 12E into the L3.

Engine: Lycoming VO-540-C2A, 305 h.p.
Rotor diameter: 35 ft 5 in (10·79 m)
Weight empty: 1,855 lb (841 kg)
Weight fully loaded: 3,100 lb (1,406 kg)
Cruising speed: 105 m.p.h. (169 k.p.h.)
Ceiling: (in ground effect) 7,500 ft (2,286 m)
Number of seats: 3

1964 SL3

This three-seater resembles the L3 but has a more powerful engine, the Lycoming TIVO-540-A2A of 315 h.p., which enables it to stand still at 12,200 feet (3,720 metres) and hover out of ground effect.

Engine: Lycoming TIVO-540-A2A, 315 h.p.
Length: 28 ft 6 in (8·69 m)
Height: 10 ft 2 in (3·1 m)
Rotor diameter: 35 ft 5 in (10·79 m)
Weight empty: 1,920 lb (871 kg)
Weight fully loaded: 3,100 lb (1,406 kg)
Cruising speed: 85 m.p.h. (137 k.p.h.)
max: 105 m.p.h. (169 k.p.h.)
Inclined climb: 910 ft/min (277 m/min)
Service ceiling: 18,300 ft (5,578 m)
Range: 220 miles (354 km)
Number of seats: 3

1963 L4

This model resembles the E4 with a new Hiller 'L' rotor control and stability system.

Engine: Lycoming VO-540-C2A, 305 h.p.
Length: 29 ft 8 in (9·04 m)
Width: 10 ft (3·05 m)
Height: 10 ft 2 in (3·1 m)
Rotor diameter: 35 ft 5 in (10·79 m)

Weight empty: 1,915 lb (869 kg)
Weight fully loaded: 3,100 lb (1,406 kg)
Cruising speed: 90 m.p.h. (145 k.p.h.)
max: 105 m.p.h. (169 k.p.h.)
Inclined climb: 970 ft/min (296 m/min)
Range: 210 miles (338 km)
Number of seats: 4

L4

1963 TL5

This prototype was developed under contract for the Canadian Army. It has the same airframe as the L4 but is equipped with a United Aircraft of Canada (Pratt and Whitney) PT6 turbine of 578 s.h.p. derated to 350 s.h.p., giving full power up to 20,000 feet (6,096 metres).

1964 SL4

This model resembles the L4, but it has a supercharger which ensures that the aircraft gives its full 315 h.p. right up to a height of 13,000 feet (3,962 metres). The first SL4 went into service late in 1964 and early 1965.

Engine: Lycoming TIVO-540-A2A, 315 h.p.
Weight empty: 2,038 lb (924 kg)
Weight fully loaded: 3,100 lb (1,406 kg)
Cruising speed: 90 m.p.h. (145 k.p.h.)
max: 105 m.p.h. (169 k.p.h.)
Inclined climb: 1,117 ft/min (340 m/min)
Ceiling: 18,600 ft (5,669 m)
Range: 194 miles (312 km)
Number of seats: 4

1950 HORNET

This two-seater was the first ram-jet helicopter developed by Hiller.

The two-bladed rotor had the Hiller Rotormatic control acting as a servo system for cyclic pitch control. The latter's control column is of the hanging type and can thus be branched for use by either of the persons flying in the rotorcraft.

Each tip of the two-bladed rotor had a ram-jet engine weighing 11 pounds (5 kilos), which cannot start working until the rotor is turning at 150 r.p.m. To achieve this speed a small petrol engine started by a pull-string was used.

The fuselage was built of steel with a plastic laminate covering, and with the rotor folded, the Hornet could be stored in a floor area of 13 by 5 feet (3·96 by 1·52 metres).

Three different prototypes were built: one completely covered in, two open. The first flight took place in 1950, but development work was postponed by the priority needs of the Korean campaign.

Engines (2): Hiller 8RJ, 35 h.p. each

Length: 12 ft 8 in (3·86 m)

Height: 6 ft 8 in (2·03 m)

HORNET

Rotor diameter: 23 ft (7·01 m)
Weight empty: 340 lb (154 kg)
Weight fully loaded: 900 lb (408 kg)
Cruising speed: 70 m.p.h. (113 k.p.h.)
Inclined climb: 1,000 ft/min (305 m/min)
Absolute ceiling: 12,000 ft (3,658 m)
Range: 50 miles (80 km)
Number of seats: 2

1952 HJ-1 (H-32 OR HOE-1) HORNET

This is the service version of the Hornet, ordered in June 1952.

By and large, it resembled the original version, but it was fitted with heavier (12·7-pound or 5·8-kilo) and more powerful engines.

The Hornet's rudder, which operated in the downwash from the rotor, was replaced by a small tail rotor giving more positive and more rapid control.

H-32 is the United States Army, HOE-1 the United States Navy designation.

Engines (2)*:* Hiller 8RJ2b ram-jets, 45 h.p. each
Rotor diameter: 23 ft (7·01 m)
Weight empty: 544 lb (247 kg)
Weight fully loaded: 1,080 lb (490 kg)

HJ-1

Cruising speed: 49·5 m.p.h. (80 k.p.h.)
max: 80·5 m.p.h. (130 k.p.h.)
Inclined climb: 1,000 ft/min (305 m/min)
Absolute ceiling: 12,000 ft (3,658 m)
Range: 35 miles (56 km)
Number of seats: 2

1956 XROE-1 ROTORCYCLE

This rotorcycle comes under the same general class as the Gyrodyne XRON-1 built by the Gyrodyne Company of America. It was developed at the request and to the order of the United States Navy.

This ultra-light helicopter has a two-bladed rotor fitted with the same 'paddle control' servo system as used on other Hiller rotorcraft.

The engine, fuel tanks and transmission system are mounted on a thick beam, from the upper part of which a metal tube runs aft and carries a small two-bladed anti-torque rotor.

The pilot's seat consists of a motor-cycle saddle set on top of the landing gear, which is of the tripod type.

This somewhat rough-and-ready helicopter can be dismantled and packed into a container suitable for transporting or parachuting. On removal from the container, the rotorcycle can be assembled ready for flight in ten minutes.

The XROE-1 was designed for observation duties with the United States Marines.

About a dozen in all of these rotorcycles were built by Saunders-Roe in Britain.

The XROE-1, one of the two designs chosen by the U.S. Navy in a 1954 competition, flew for the first time in November 1956.

Engine: Nelson H-63, 45 h.p.
Width: 8 ft 4 in (2·54 m)
Height: 6 ft 10⅝ in (2·1 m)
Rotor diameter: 18 ft 6 in (5·64 m)
Weight empty: 300 lb (136 kg)
Weight fully loaded: 496 lb (225 kg)
Cruising speed: 52 m.p.h. (84 k.p.h.)
max: 70 m.p.h. (113 k.p.h.)
Inclined climb: 1,160 ft/min (354 m/min)
Service ceiling: 13,160 ft (4,011 m)
Range: 40 miles (64 km)
Number of seats: 1

1960 TEN 99

The Ten 99 prototype multi-purpose helicopter had external dimensions comparable to the three-seater Model 12E, even though it can carry six

XROE-1 ROTORCYCLE

people. This was possible only because the shaft-turbine was mounted above the fuselage. In addition it had aft clamshell doors, four other large doors and a cargo hook. The rotor has two blades and is auto-stabilized; the anti-torque rotor is placed at the end of a tubular boom with inverted vee tail fins.

The maiden flight took place in 1961.

Engine: Pratt and Whitney PT6, 500 s.h.p.
Length: 29 ft 4 in (8·94 m)
Width: 8 ft 6 in (2·59 m)
Height: 10 ft 5 in (3·17 m)
Rotor diameter: 35 ft 7 in (10·84 m)
Weight empty: 1,900 lb (862 kg)
Weight fully loaded: 3,500 lb (1,588 kg)
Number of seats: 6

1961 CAMEL (PROJECT)

CAMEL is a proposal by Hiller for a Collapsible Airborne Military Equipment Lifter. It was presented in May 1962 as a mock-up to prove that it could be assembled in 8 minutes and that furthermore its size once it is collapsed makes it possible to carry 16 of these Camels as packages in one C-130.

Designed to carry five men or equipment in addition to the pilot, this foldable helicopter weighs 3,000 pounds (1,360 kilos) and is to be powered by an Allison T63 turbine.

1962 OH-5A

The Hiller OH-5A took part in the United States Army's Light Observation Helicopter (LOH) Competition with the Hughes OH-6A and the Bell OH-4A. The Hiller OH-5A made its maiden flight in January 1963. It has a two-bladed semi-rigid teetering rotor with the same automatic stabilizing system as the L4. This is of great advantage in a military aircraft because it relieves the pilot of all need constantly to attend to cyclic controls, thus leaving him free to devote the greater part of his time to his actual mission.

The doors on either side covering the automatic stabilizer system also serve, when open, as maintenance platforms for access to the engine top and transmission. The lightweight fibreglass engine-cowling slides aft for routine inspection and maintenance.

The cabin has no bulkhead to separate crew from passengers. The rear seats can be folded away to leave room for 400 pounds (181 kilos) of cargo.

The OH-5A was one of the finalists in the LOH competition, the winner of which was however named during 1965 as the OH-6A.

Engine: Allison T63-A-5, 250 s.h.p.
Length: 30 ft 1 in (9·17 m)
Width: 7 ft 3 in (2·21 m)
Height: 9 ft 4 in (2·84 m)
Rotor diameter: 35 ft 5 in (10·79 m)
Weight fully loaded: 2,500 lb (1,134 kg)
Cruising speed: 125 m.p.h. (201 k.p.h.)
max: 140 m.p.h. (225 k.p.h.)
Range: 375 miles (604 km)
Number of seats: 4

1965 FH-1100

This civil version of the OH-5A helicopter is a natural step forward from the 4-seater SL4, using the same SAS rotor system.

This Fairchild-Hiller light commercial rotorcraft powered by a turbine was shown to the public for the first time at the Le Bourget Air Show in 1965. The turbine develops 2·4 h.p. per pound of engine weight.

Hydraulically-boosted and collective controls enhance the helicopter's ease of flight; should the boost and stability augmentation systems fail, the FH-1100 handles like a less sophisticated helicopter.

The Royal Netherlands Navy is evaluating this rotorcraft for use as an anti-submarine weapon delivery system.

Engine: Allison 250-C18, 317 s.h.p.
Length: 30 ft 1 in (9·17 m)
Width: 7 ft 3 in (2·21 m)
Height: 9 ft 2 in (2·79 m)
Rotor diameter: 35 ft 5 in (10·79 m)
Weight empty: 1,370 lb (621 kg)
Weight fully loaded: 2,530 lb (1,148 kg)
Cruising speed: 120 m.p.h. (193 k.p.h.)
max: 128 m.p.h. (206 k.p.h.)
Inclined climb: 1,850 ft/min (564 m/min)
Service ceiling: 17,200 ft (5,243 m)
Range: 362 miles (583 km)
Number of seats: 4

FH-1100

HOPPICOPTER

This company was formed in December 1945 to develop the idea of an ultra-light individual helicopter conceived by Horace Pentecost, who had designed an aircraft of this type and held full rights in it.

The earliest prototype was a portable helicopter, which was attached to the flier's back by straps and harness, and which had no landing gear.

The second model on the same general lines was also fitted with a motor-cycle saddle acting as the pilot's seat, and a tubular tripod assembly with three wheels as landing gear. It was this version which was developed further. The British Ministry of Supply, incidentally, showed interest in aircraft of this kind and two Hoppicopter models were sent to the United Kingdom for testing.

A new type of helicopter, powered by small pulse-jet engines at the blade tips, was also developed by Horace Pentecost. He had then left the Hoppicopter concern, though retaining rights in his inventions, and

become President of the Capital Helicopter Corporation, founded in 1954.

1945 HOPPICOPTER 'STRAP-ON'

This ultra-light individual helicopter had two co-axial contra-rotating two-bladed rotors powered by a small two-stroke horizontally opposed engine developing about 20 h.p.

The body consisted of a tubular metal frame curved to fit over the pilot's shoulders and attached to the body by a harness of the type employed in parachutes; the pilot's legs were used for landing.

Some twenty hops were made with the use of safety cables attached to the pilot, but this strap-on helicopter ended its career in the Smithsonian Institution in Washington.

Engine: 20 h.p.
Rotor diameter: 12 ft (3·66 m)
Weight fully loaded: 200 lb (91 kg)
Number of seats: 1

HOPPICOPTER 'STRAP-ON'

1946 MODEL 101

This model reproduced the main general features of the 'Strap-on', but the pilot now had a seat and a tubular tripod assembly with three small wheels to act as landing gear, and also a hanging stick to control the aircraft.

Engine: 20 h.p.
Rotor diameter: 16 ft (4·88 m)
Number of seats: 1

1947 MODEL 102

Tests of the Model 101 revealed the need for several improvements, so that the 102, while somewhat resembling its predecessor, had a more powerful engine. Besides a directly engaging clutch, there was also a freewheeling device for auto-rotation in case of engine failure.

The two rotors, set at a distance of 2 feet (61 centimetres) from each other, consisted of a 4-foot (1·22-metre) tubular metal section centred at the hub; to these tubular sections the two spruce blades were attached.

The controls included collective, cyclic and differential pitch, the latter being obtained by rotating the stick handle which made the helicopter turn on its vertical axis.

Engine: 35 h.p.
Height: 8 ft (2·44 m)
Rotor diameter: 16 ft 6 in (5·03 m)
Number of seats: 1

1947 MODEL 103

This model was similar to the previous ones, except that the rotor diameter was slightly increased and the distance between the two rotors somewhat greater.

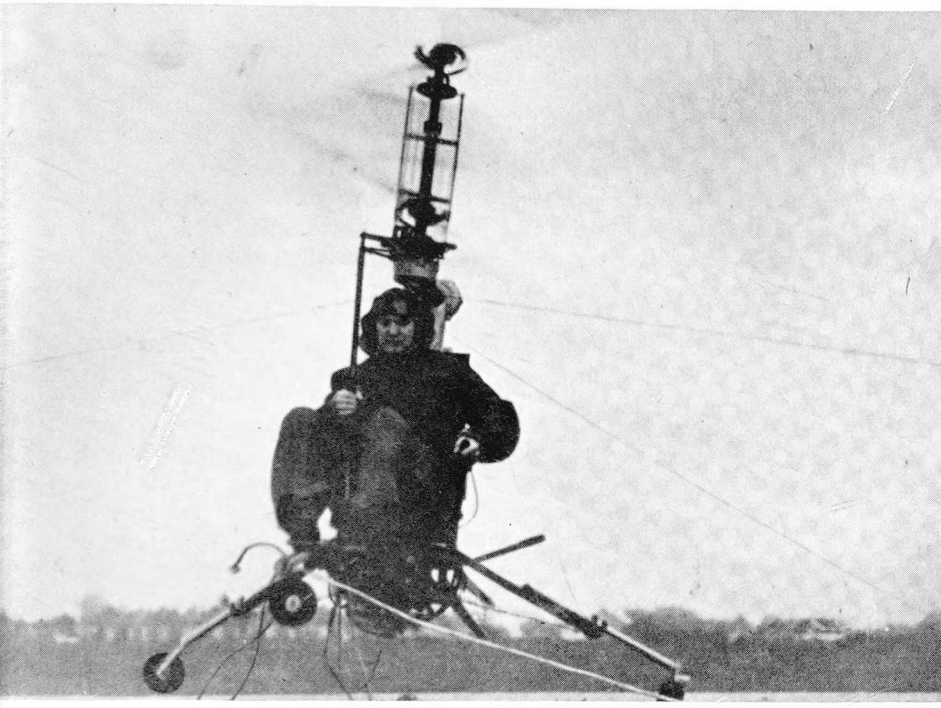
Engine: 40 h.p.
Rotor diameter: 17 ft (5·18 m)
Weight empty: 194 lb (88 kg)
Weight fully loaded: 430 lb (195 kg)
Number of seats: 1

1948 MODEL 104

Once again this was an ultra-light single-seater helicopter with two co-axial contra-rotating two-bladed rotors of the same lineage as the firm's previous products.

Model 104 was sent to the United Kingdom, where it remained, to be tested for the Ministry of Supply under the aegis of a British company, Hoppicopter Ltd (see under Great Britain).

Engine: 40 h.p.
Rotor diameter: 17 ft (5·18 m)



MODEL 103

Weight empty: 190 lb (86 kg)
Weight fully loaded: 425 lb (193 kg)
Cruising speed: 45 m.p.h. (72 k.p.h.)
Range: 150 miles (241 km)
Number of seats: 1

HUGHES

In 1936, following the success of the Hughes racing aircraft, which in 1935 set up a world speed record of 352 m.p.h. (566 k.p.h.), the Hughes Aircraft Company was set up as a division of the important Hughes Tool Company.

In 1942 this division started to build the world's largest flying-boat with a wing span of 320 feet (97·5 metres) and a length of 219 feet (66·75 metres), tests of which were not started until 1947.

Later Hughes acquired from Kellett the patent rights relating to the KH-17 'Sky Crane'. Tests of the first Hughes heavy-cargo helicopter began in 1950.

1949 XH-17

By the middle of 1950 this experimental heavy-cargo helicopter had completed its ground testing with the rotor running up to its normal operating speed of 88 r.p.m. In the interim, Hughes had obtained a United States Air Force contract to develop the ground test stand into the XH-17 flying test stand, which, it was hoped, would provide a valuable source of flight data for future large pressure-jet helicopters.

The first flight actually took place in October 1952.

This heavy-lift rotorcraft was of gigantic height and rotor size and was powered by two turbojets, one on each side of the fuselage. These General Electric power plants had been modified to supply gas pressure through ducts leading up the rotor shaft and out to the General Electric 33-F burners on the tips of the rotor blades. There was also a tail rotor driven from the main rotor.

The stilt-like legs leave an unobstructed space for cargo beneath the helicopter's belly so that payloads of up to 27,000 pounds (12,247 kilos) could be transported.

XH-17

Engines (2): GE J35 turbojets
Rotor diameter: 130 ft (39·62 m)
Weight fully loaded: 52,000 lb (23,587 kg)
Cruising speed: 60 m.p.h. (97 k.p.h.)
Inclined climb: 800 ft/min (244 m/min)
Absolute ceiling: 15,000 ft (4,572 m)
Range: 40 miles (64 km)
Number of seats: 2

1956 HUGHES 269 (YHO-2HU)

This helicopter is at the opposite end of the size scale from the XH-17. It actually is a small light helicopter fitted with a three-bladed rotor. The metal blades are fully articulated and of bonded wrap-round skin construction. The use of a vee-belt makes it unnecessary to use a clutch. The engine is placed partially beneath the seats.

The objective sought for in this aircraft, built as a private venture, was to make it very simple and thus keep down to the minimum both initial and operating costs. The prototype made its maiden flight in the last quarter of 1956.

In the mass-production model with the designation 269A, the prototype's welded steel structure was replaced by a braced tubular tail boom. This helicopter foreshadowed the Hughes 200 and 300 series. By 1964, more than 300 had been built.

Under the designation YHO-2HU, it was evaluated by the U.S. Army.
Engine: Lycoming O-360-B1B, 180 h.p.
Length: (overall) 22 ft 3 in (6·78 m)
Height: 7 ft 11 in (2·41 m)
Rotor diameter: 25 ft 3½ in (7·71 m)
Weight empty: 910 lb (413 kg)
Weight fully loaded: 1,550 lb (703 kg)
Cruising speed: 83 m.p.h. (134 k.p.h.)
max: 86 m.p.h. (138 k.p.h.)
Inclined climb: 1,450 ft/min (442 m/min)
Ceiling: 11,000 ft (3,353 m)
Range: 200 miles (322 km)
Number of seats: 2

1964 HUGHES 200 (TH-55A)

Formerly known as Model 269A, the Hughes 200 successfully carried out an endurance test lasting 101 hours 5 minutes at Beaconsfield, California. Pilot changes and refuelling took place while the aircraft hovered about 4 feet (1·2 metres) above the ground.

The Hughes 200 exists in three different versions. For civilian use there is a luxury and also a utility model. Both of these are equipped with

a Lycoming HIO-360-B1A fuel-injection engine. The third version, known as the TH-55A, is a U.S. Army primary helicopter trainer.

1964 HUGHES 300 (269B)

This helicopter is a Model 269 in a three-seater version. It was specially designed to carry optional equipment such as floats, stretchers, cargo racks and an external load sling.

Another model, the 300 Ag, was designed for agricultural spraying operations. It carries a spray system with a 35-foot (10·7-metre) boom.

Engine: Lycoming HIO-360-A1A, 180 h.p.
Length: (overall) 22 ft 4 in (6·81 m)
Width: 6 ft 6½ in (2 m)
Rotor diameter: 25 ft 3½ in (7·71 m)
Weight empty: 950 lb (431 kg)
Weight fully loaded: 1,670 lb (757 kg)
Cruising speed: 80 m.p.h. (129 k.p.h.)
max: 86 m.p.h. (138 k.p.h.)
Inclined climb: 1,450 ft/min (442 m/min)
Service ceiling: 14,000 ft (4,267 m)
Range: 180 miles (290 km)
Number of seats: 2–3

1966 HUGHES 280U

The 280U is a single-seater agricultural version, with agricultural equipment which can be fitted onto other Hughes two- or three-seater helicopters.

1962 HUGHES 369 (OH-6A CAYUSE)

The Hughes OH-6A, the model designation of which is Hughes 369, won the U.S. Army Light Observation Helicopter Competition, for which designs by Hughes, Bell and Hiller had been selected in 1961 to take part.

One unusual feature of the OH-6A is its four-bladed fully articulated rotor with an offset flapping hinge. Each pair of the diametrically opposed blades is connected by laminated stainless steel straps which provide feathering and flapping movement and thus eliminate all thrust bearings from the rotor head. Central force is centred by the straps and not the hub, which merely performs a torque function.

The external configuration has been kept as small as the design requirements allowed. The fuselage is of semi-monocoque construction; within its main fuselage the engine is mounted and covered by part of the upper portion. Although this helicopter is small, it has a 40 cubic foot- (1·1 cubic metre-) cargo compartment placed beneath the main rotor mast.

The landing gear consists of individual oleo shock-absorber legs attached to tubular skids.

The maiden flight took place in March 1963. During 1966 this helicopter set up a series of world records, for distance in closed circuit (2,800·2 kilometres), distance in a straight line without landing (3,561·55 kilometres), speed over a closed circuit of 2,000 kilometres (227·74 k.p.h.) and maximum altitude maintained in horizontal flight (8,061·3 metres).

The first deliveries of this light observation and combat support helicopter started in September 1966.

Engine: Allison T63-A-5, 250 s.h.p.
Length: (fuselage) 23 ft (7·01 m)
Width: (fuselage) 4 ft 7 in (1·4 m)
Height: 8 ft 5 in (2·57 m)
Rotor diameter: 26 ft 4 in (8·03 m)
Weight empty: 1,156 lb (524 kg)
Weight fully loaded: 2,400 lb (1,089 kg)
Cruising speed: 143 m.p.h. (230 k.p.h.)
Rate of climb: 1,550 ft/min (472 m/min)
Service ceiling: 15,500 ft (4,724 m)
Range: 400 miles (644 km)
Number of seats: 4

OH-6A

1965 HUGHES 500

The Hughes 500 is a commercial version of the OH-6A light helicopter planned in 1965 in two versions: Model 500, Executive Transport Helicopter; and Model 500U, Utility Helicopter. It was later planned in the following versions: 1968, 500M international military version; 1969, 500E, commercial helicopter and 500S standard ship.

The weight of the 500 when empty is 1,041 pounds (472 kilos), that of

the 500U only 988 pounds (448 kilos). The 500U resembles the 500 but lacks rear seats or anything to take their place. It can lift weights of up to 1,019 pounds (462 kilos) on the outside of the cabin. Nardi S.A. of Italy and Kawasaki of Japan are licensed to manufacture the 500.

Engine: Allison 250-C18, 317 s.h.p.
Length: (fuselage) 23 ft (7·01 m)
Width: 6 ft 9 in (2·06 m)
Height: 8 ft $1\frac{1}{4}$ in (2·47 m)
Rotor diameter: 26 ft 4 in (8·02 m)
Weight empty: 1,041 lb (472 kg)
Weight fully loaded: 2,400 lb (1,089 kg)
Cruising speed: 150 m.p.h. (241 k.p.h.)
Inclined climb: 1,870 ft/min (570 m/min)
Range: 450 miles (724 km)
Number of seats: 5

MODEL 500

1964 HUGHES 385 (XV-9A)

The XV-9A is a hot-cycle research helicopter. It is propelled by ducting the energy gases from a turbojet engine to the rotor tips, where they are exhausted. Thus no combustion takes place there as it did in Hughes' first helicopter, the XH-17.

The rotor for the XV-9A was developed on the TRECOM (U.S. Army Transportation Research Command) test bed. For each of the two gas generators a diverter valve makes it possible either to feed the rotor or to eject the gases directly towards the tail. In the latter case the gas generators act as ordinary turboreactors used to propel the rotorcraft.

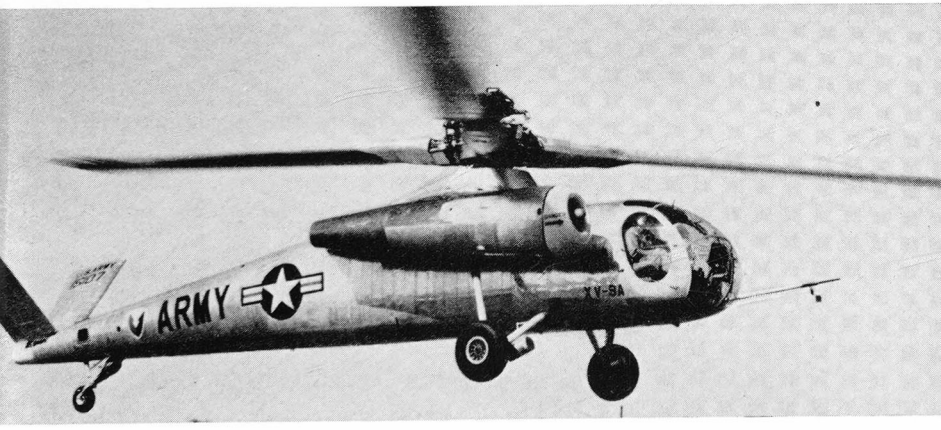
The three rotor blades have louvred openings at the tip. Each of the large side blades consists of two spars, one fore, one aft. Between them are two ducts, externally cooled with air pumped by centrifugal force.

There is no tail rotor; yaw control is provided by a gas diverter pipe running right to the tail. At the tail there is a V-shaped tail rudder fitted with controls, while the tricycle landing gear is of the Sikorsky S-58 type.

Test flights began in November 1964.

Hughes plan to apply this principle to various applications such as multi-purpose vehicles, heavy lift and hot-cycle compound helicopters.

Engines (2)*:* General Electric T64-GE-6, 2,850 s.h.p.
Length: 45 ft (13·72 m)
Height: 12 ft (3·66 m)
Rotor diameter: 55 ft (16·76 m)
Weight unloaded: 8,500 lb (3,856 kg)
Weight fully loaded: 15,300 lb (6,940 kg)
Cruising speed: (max.) 170 m.p.h. (274 k.p.h.)
Number of seats: 2



XV-9A

JACOBS

Since 1929 the Jacobs Aircraft Engineering Company has specialized in the manufacture of radial air-cooled engines, large numbers of which, incidentally, were used on autogyros.

A few years ago Jacobs set up a helicopter division, which in 1953 produced the Jacobs 104, a convertiplane of original design.

1953 JACOBS 104

This convertiplane is of unusual appearance, since it is fitted with wings and has a pusher propeller.

The power source, built by Jacobs, has been modified to form a compact unit incorporating the transmission system as part of the basic engine.

The latter drives a three-bladed main rotor with collective and cyclic variable pitch, a three-bladed tail rotor 6 feet (1·83 metres) in diameter, and a three-bladed pusher propeller 6 feet 5 inches (1·96 metres) in diameter. It should be observed that the anti-torque rotor intermeshes with the pusher propeller.

This convertiplane has swept-back aluminium wings, which can be removed. In translational flight, the rotor turns by auto-rotation, while the pusher propeller operates from the engine. Of the total lift, 30 per cent is supplied by the wings.

The first flights took place in October 1953.

Engine: Jacobs R-755-E, 350 h.p.
Width: 18 ft 2 in (5·54 m)
Height: 10 ft 10 in (3·3 m)
Rotor diameter: 36 ft (10·97 m)
Weight empty: 1,972 lb (894 kg)
Weight fully loaded: 3,258 lb (1,478 kg)
Cruising speed: 150 m.p.h. (241 k.p.h.)
Inclined climb: 1,130 ft/min (344 m/min)
Absolute ceiling: 14,000 ft (4,267 m)
Range: 376 miles (605 km)
Number of seats: 5

JENSEN

The Jensen Helicopter Corporation was formed by Martin Jensen for the purpose of developing his Model 21 helicopter.

1948 MODEL 21

This prototype, which first flew in April 1948, had two co-axial contra-rotating two-bladed rotors, revolving at 344 r.p.m.

Engine: Continental C-125, 125 h.p.
Rotor diameter: 27 ft (8·23 m)
Weight empty: 1,050 lb (476 kg)
Weight fully loaded: 1,550 lb (703 kg)
Cruising speed: 80 m.p.h. (129 k.p.h.)
max: 100 m.p.h. (161 k.p.h.)
Absolute ceiling: 10,000 ft (3,048 m)

Range: 200 miles (322 km)
Number of seats: 2

JOVAIR

Jovanovich's original idea was to build a small helicopter with two contra-rotating rotors, the upper with three blades, the lower and much smaller one with two blades. This rotorcraft was also to have a tail rotor and be driven by a power unit located in the nose, with the pilot placed just below the rotor system.

This idea was never given concrete form, but Jovanovich and his Helicopter Engineering Research Corporation, the staff of which came from the Piasecki Helicopter Corporation, did develop a small, two-seater helicopter with rotors in tandem, the JOV-3. This rotorcraft flew successfully and was later taken over by the McCulloch Company which used it as the starting-point for its own MC-4. Later this rotorcraft was taken up again and led to the Jovair 4E. Jovair is the trade name for the Jovair Corporation of Culver City, which markets the output of Jovanovich and his team.

1946 JOV-3

This small two-seater had two three-bladed rotors set in tandem. The blades were of wood construction, which contained a longitudinal steel tube and an aluminium trailing edge.

The aft rotor's position was slightly higher than that of the forward rotor so as to reduce the latter's downwash effect during horizontal flight.

The fuselage of welded steel tubes was entirely covered, and there was a tricycle undercarriage.

Engine: Franklin, 100 h.p.
Length: 26 ft 4 in (8·03 m)
Height: 9 ft 3 in (2·82 m)
Rotor diameter: 18 ft 6 in (5·64 m)
Weight empty: 780 lb (354 kg)
Weight fully loaded: 1,200 lb (544 kg)
Cruising speed: 73 m.p.h. (117 k.p.h.)
max: 100 m.p.h. (161 k.p.h.)
Inclined climb: 1,290 ft/min (393 m/min)
Absolute ceiling: 14,000 ft (4,267 m)
Range: 138 miles (222 km)
Number of seats: 2

1961 JOVAIR SEDAN 4E

This is a further development of the JOV-3, known as the MC-4 at

McCulloch. This small tandem-rotor helicopter is powered by an engine mounted horizontally with fan cooling in the rear fuselage. The engine drives, by means of belts, two rotors, each with three fully-articulated blades. The tail is equipped with two vertical booms.

The Sedan 4E has a 210 h.p. Franklin 6A-335 engine and the Sedan 4ES a supercharged Franklin 6AS-335 engine of 225 h.p. Both of these were fully FAA certified in 1963.

The Jovair 4E is also made in a 4U utility version and a 4A agricultural version. In these versions the fuselage is not covered.

Engine: Franklin 6A-335, 210 h.p.
Length: (fuselage) 18 ft (5·49 m)
Height: 8 ft 3 in (2·51 m)
Rotor diameter (2)*:* 23 ft (7·01 m)
Weight empty: 1,463 lb (664 kg)
Weight fully loaded: 2,300 lb (1,043 kg)
Cruising speed: 80 m.p.h. (129 k.p.h.)
max: 90 m.p.h. (145 k.p.h.)
Inclined climb: 800 ft/min (244 m/min)
Ceiling: 12,500 ft (3,810 m)
Range: 250 miles (402 km)
Number of seats: 4

1961 J2

This small autogyro has a pusher propeller between the tail booms supported by short stub wings. With its two side-by-side seats in an enclosed cabin, it made its maiden flight in June 1962.

Engine: Lycoming O-360, 180 h.p.
Length: 16 ft (4·88 m)
Height: 8 ft 6 in (2·59 m)
Rotor diameter: 27 ft (8·23 m)
Weight empty: 810 lb (367 kg)
Weight fully loaded: 1,360 lb (617 kg)
Cruising speed: 110 m.p.h. (177 k.p.h.)
max: 125 m.p.h. (201 k.p.h.)
Inclined climb: 1,000 ft/min (305 m/min)
Range: 300 miles (483 km)
Number of seats: 2

KAMAN

Late in 1945, after spending five years as head aerodynamicist in the rotor section of United Aircraft's Hamilton Standard Propellers, Charles Kaman set up in Connecticut his own company: the Kaman Aircraft Corporation.

The helicopters which he then set about building were fitted with two-bladed contra-rotating intermeshing rotors. Blade-pitch control is obtained, not as in many helicopters by means of a 'spider' let into the axis, but through the use of small servo-flaps mounted three-quarters of the way along each rotor. These flaps behave like tabs and twist the spruce blades when worked by the pilot. All the helicopters produced by Kaman are fitted with this system, which makes them aerodynamically servo-controlled.

An interesting sideline to helicopters is Kaman's development in 1954 of the 'rotachute', a device which enables supplies to be dropped from aircraft with pinpoint accuracy on any given spot. The 'rotachute' is intended to replace the parachute normally attached to dropping containers. It consists of blades which open out soon after release and then turn by auto-rotation.

Kaman also broke away from his traditional intermeshing configuration by developing a single-rotor helicopter with blades having the proven Kaman servo-flaps.

In addition, at the time of the British Rotodyne developed by Fairey, Kaman in 1959 became the sole United States licensee and representative for the Fairey Aviation Company.

1946 K-125

The data that Kaman obtained from his test bench, consisting of an old motor-car chassis and a two-bladed rotor, enabled him to build his first helicopter, the K-125, with intermeshing contra-rotating rotors. It flew for the first time on 15 January 1947, even before its fuselage was completed. In appearance it was then an uncovered metal skeleton with an engine and tricycle landing gear.

While this engine was carrying out its first flights for the purpose of checking the behaviour of its rotors and special control systems, Kaman set about building the K-190.

1948 K-190

This three-seater successor to the foregoing two-seater had, like it, a somewhat skeletal appearance with its skinless steel tube structure. The accommodation for two passengers consisted of a bench placed behind the pilot, who was himself in the extreme forepart of the aircraft in an extremely sketchy cockpit. There was an imposing tail fin fitted with a rudder.

Engine: Lycoming O-435, 195 h.p.
Rotor diameter: 38 ft (11·58 m)
Weight empty: 1,700 lb (771 kg)
Weight fully loaded: 2,500 lb (1,134 kg)
Cruising speed: 65 m.p.h. (105 k.p.h.)

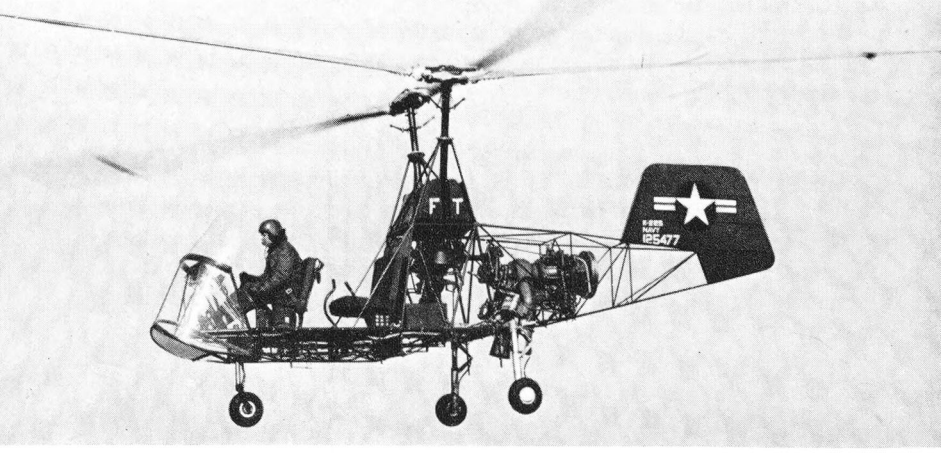
Absolute ceiling: 11,000 ft (3,353 m)
Range: 235 miles (378 km)
Number of seats: 3

1948 K-225 (YH-22)

This version, the commercial counterpart to the previous one, showed no major changes from it, apart from a more powerful piston engine. The first flights took place in December 1948.

For use in the U.S. Navy, one of these helicopters was powered by a Boeing 502-2 gas-turbine developing 175 h.p. for continuous operation. This variant, which made its maiden flight at the end of 1951, was America's first turbo-rotor helicopter. The turbine installations employed here have marked similarities with turboprop installations in ordinary aircraft. A further interesting detail is that only minor changes in the fuel system would enable propane or natural gas fuel to be used. The variants introduced have resulted in considerably better performance figures than obtained with the ordinary Kaman. Most of the improvements were undoubtedly due to the great saving in weight of the gas-turbine power source: the latter weighed less than half as much as the piston-engine installation.

Engine: Lycoming O-435-A2, 220 h.p.
Length: 23 ft (7·01 m)
Height: 11 ft (3·35 m)
Rotor diameter: 38 ft (11·58 m)
Weight empty: 1,800 lb (816 kg)
Weight fully loaded: 2,700 lb (1,225 kg)



K-225

Cruising speed: 65 m.p.h. (105 k.p.h.)
max: 73 m.p.h. (117 k.p.h.)
Inclined climb: 1,000 ft/min (305 m/min)
Absolute ceiling: 12,000 ft (3,658 m)
Range: 194 miles (312 km)
Number of seats: 3

1950 K-240 (HTK-1)

This helicopter, which has been in service with the U.S. Navy since early 1952, differs from its forerunners in having a tailplane synchronized with the collective blade-pitch control. In addition, the mass-produced version has three fins, supported on a single beam instead of on two as in the prototype.

As a result of a joint Army-Navy project, a standard model was altered by installing two Boeing 502-2 gas-turbine engines. These twin turbines, together producing 350 h.p., are mounted side-by-side in exactly the same position as the piston engine which they replace. For vertical take-off or for hovering with a heavy load, both turbines operate simultaneously; for forward flight one can be shut off. This modified HTK-1, the first U.S.A. twin-turbine rotorcraft, made its first flight on 26 March 1954.

Another interesting development is remote-control flying. For this purpose Kaman produced a small automatic pilot.

K-240 is the designation of the standard civil model.
Engine: Lycoming O-435-4, 235 h.p.
Rotor diameter: 41 ft (12·5 m)

K-240

Weight fully loaded: 2,500 lb (1,134 kg)
Cruising speed: 70 m.p.h. (113 k.p.h.)
Inclined climb: 700 ft/min (213 m/min)
Absolute ceiling: 10,000 ft (3,048 m)
Range: 194 miles (312 km)
Number of seats: 3

1950 K-600 (HOK-1, HUK-1, H-43A)

This helicopter was also ordered by the U.S. Navy, and is markedly more powerful than its predecessor. It retained the earlier version's transmission system: a primary shaft ending in a reduction and distribution box which imparted movement to the two two-bladed rotors. The heads of the latter were much closer together than in the HTK-1, the intervening distance being only 3 feet 3 inches (1 metre) instead of 3 feet 9 inches (1·14 metres), as in the HTK-1. The HOK-1 also had ventral and dorsal fins.

The HOK-1 was chosen by the U.S. Air Force to act as a test bed for the first trials of the Lycoming XT53 'free' type of gas-turbine developed jointly by the U.S. Army and Air Force for use on helicopters. This turbine increases the interior cabin space available by being mounted above the fuselage, since the piston engine is mounted behind it. The turbine-powered model first flew in 1956. The United States Department of Defense has decided upon the following designations of the K-600:

The Marine Corps version, formerly known as HOK-1, is now designated OH-43D. The Navy helicopter, formerly HUK-1, has become UH-43C. The United States H-43A version crash rescue helicopter is now the HH-43A, and the final deliveries of the piston-engine rescue

K-600 (HOK-1)

helicopter were made to the United States Air Force during the summer of 1959.

Engine: Pratt and Whitney R-1340-48, 600 h.p.
Length: (fuselage) 25 ft (7·62 m)
Width: 9 ft $0\frac{3}{4}$ in (2·77 m)
Height: 12 ft 6 in (3·81 m)
Rotor diameter (2)*:* 47 ft (14·33 m)
Weight empty: 4,380 lb (1,987 kg)
Weight fully loaded: 5,580 lb (2,531 kg)
Cruising speed: 75 m.p.h. (121 k.p.h.)
Inclined climb: 1,480 ft/min (451 m/min)
Ceiling: 22,000 ft (6,706 m)
Range: 220 miles (354 km)
Number of seats: 5

1956 HH-43B HUSKIE

The Huskie (K-600-3), formerly known as H-43B, is the successor to the United States Air Force Class HH-43A. The use of a gas-turbine mounted aft of the rotor pylon has enabled this rotorcraft to reduce its overall weight and increase its payload capacity, while retaining the same size as the HH-43A.

Also retained is the intermeshing rotor configuration with each rotor of the two-bladed teetering type.

The HH-43B, specially designed as a crash rescue vehicle, usually carries the following special equipment: rescue hoist; provision for a total of four stretchers; crash entry kit to remove trapped airmen; fire-fighting kit; external hot cargo hook and rescue floodlights. Its widest use is in the United States Air Force units responsible for the Air Rescue Service which employ it mainly in local base crash rescue work.

On 18 October 1961 an HH-43B Huskie, piloted by Lt-Col Francis M. Carney, reached a record height of 32,800 feet (10,000·6 metres) at the Kaman Heliport, Bloomfield, Connecticut, sub class, 1,750-3,000 kg.

The designation of the Huskie (K-600-4), when equipped with a more powerful turbine, a 1,100 s.h.p. T53L-11, is HH-43F. This version's maiden flight was in August 1964. It is in service with the U.S. Air Force as a rescue craft.

Engine: Lycoming T53-L-1B, 860 s.h.p.
Length: (fuselage) 25 ft 2 in (7·67 m)
Width: 8 ft 4 in (2·54 m)
Height: 12 ft 7 in (3·84 m)
Rotor diameter: 47 ft (14·33 m)
Weight empty: 4,469 lb (2,027 kg)
Weight fully loaded: 8,800 lb (3,992 kg)
Cruising speed: 109 m.p.h. (175 k.p.h.)

Inclined climb: 1,460 ft/min (445 m/min)
Service ceiling: 25,000 ft (7,622 m)
Range: 270 miles (435 km)
Number of seats: 12

H-43B

1962 MODEL 1125 HUSKIE III

This prototype with an intermeshing rotor was developed from the HH-43B, of which it uses 85 per cent of the dynamic components. The major elements of the fuselage are the same. It has the same transmission with only minor modifications to provide for the second engine driveshaft and also a generator take-off drive in a different position. It also has a single tail boom with a moveable rudder and stabilizer surfaces. There is an integral rear-loading ramp with passenger stairs.

By contrast, the cabin here differs from its predecessor in being 17 inches (43·18 centimetres) longer and 7 inches (17·78 centimetres) higher. In the executive version it can carry six passengers or as many as twelve in a version with folding seats.

The maiden flight took place during the summer of 1962.
Engines (2)*:* Boeing YT60, 500 s.h.p. each
Length: 39 ft 3 in (11·96 m)
Width: 8 ft 6 in (2·59 m)

Height: 14 ft 4 in (4·37 m)
Rotor diameter (2)*:* 47 ft (14·33 m)
Weight empty: 5,232 lb (2,373 kg)
Weight fully loaded: 10,500 lb (4,763 kg)
Cruising speed: 121 m.p.h. (195 k.p.h.)
max: 138 m.p.h. (222 k.p.h.)
Range: 390 miles (628 km)
Number of seats: 8–14

1957 K-17

This helicopter, developed as a joint United States Army–Kaman project, was powered by a Turmo 600 gas-turbine driving a Boeing compressor located in the fuselage. Air from the compressor is ducted through a rotating seal to the rotor hub and ejected without combustion from the tips of the rotor's two blades.

The small tail rotor—a fixed-pitch propeller—is used for steering only. Driven by a hydraulic pump, it reverses its rotational direction in response to the pilot's rudder pedals, thus producing thrust for turning the helicopter.

This experimental research helicopter made its maiden flight in the spring of 1958.

Engine: Turboméca Turmo 600, 400 s.h.p.
Height: 8 ft 6 in (2·59 m)
Rotor diameter: 37 ft (11·28 m)
Weight empty: 950 lb (431 kg)
Weight fully loaded: 2,000 lb (907 kg)
Cruising speed: (max.) 80 m.p.h. (129 k.p.h.)
Number of seats: 2

1957 K-20 (UH-2A SEASPRITE)

The design of this helicopter started in 1957. It was intended to take part in a United States Navy competition for a high-speed, all-weather utility helicopter to be used on a great variety of missions dictated by widely dispersed modern naval operations. Formerly known as the HU2K-1, it was developed by Kaman and the United States Navy Bureau of Aeronautics.

The Seasprite abandons the customary intermeshing-rotor system for the more conventional main rotor and anti-torque tail rotor. The four-bladed main rotor uses servo flaps on the outboard trailing edge of each blade to control flight.

A flotation hull ensures safety on water; inside the wheel-well fairings on either side of the helicopter are two inflatable rubber sponsons. Retractable gear and trim fuselage lines give the Seasprite relatively high cruising speeds.

It made its maiden flight in July 1959 and entered into service at the end of 1962.

An armed version of the UH-2 for tactical escort missions, designated as the Tomahawk by the United States Army, was evaluated in 1963–4. In this version navigation and rescue equipment has been replaced by rocket pods and machine guns.

Early in 1965 a twin-turbine version of the Seasprite made its first appearance. This variant, known as the UH-2C, has two T58 engines mounted at the same height but outboard and forward of the previous single T58 on the mass-produced UH-2. Flight tests were satisfactorily completed towards the end of 1966.

Another interesting variant is the compound Seasprite developed under a joint Army Transportation Research Command and Bureau of Naval Weapons programme to investigate the Seasprite rotor system's high-speed potential. A UH-2 was modified by adding a 2,500-pound thrust GE YJ85 jet pod mounted on the starboard side of the fuselage. Speeds in excess of 215 miles per hour (346 k.p.h.) have been achieved. Later, wings were fitted to this high-speed compound research helicopter.

Engine: General Electric T58-GE-8B, 1,250 s.h.p.
Length: (fuselage) 36 ft 7 in (11·15 m)
Height: 12 ft 4 in (3·76 m)
Rotor diameter: 44 ft (13·41 m)
Weight empty: 5,149 lb (2,336 kg)
Weight fully loaded: 10,680 lb (4,844 kg)
Cruising speed: 152 m.p.h. (245 k.p.h.)

UH-2 SEASPRITE

Inclined climb: 2,100 ft/min (640 m/min)
Service ceiling: 17,400 ft (5,304 m)
Range: 550 miles (885 km)
Number of seats: 14

KELLETT

Since its foundation in 1929 by W. Wallace Kellett, with Richard H. Prewitt as chief engineer, the Kellett Aircraft Corporation's activities have always been in the rotary-wing field. As licensee of the Autogiro Company of America, Kellett produced a whole series of autogyros designed by Prewitt.

One of them accompanied the 1934 expedition to the South Pole led by Rear-Admiral R. E. Byrd. In 1935 a Kellett autogyro carrying mailbags gave take-off demonstrations from the roof of the Philadelphia Post Office. Later, Eastern Airlines operated a direct mail transfer service between the Philadelphia Post Office roof and Camden airport.

At about the time of the United States' entry into World War II Kellett was producing a direct-take-off autogyro, and in 1948 the company delivered to the United States Air Force the XR-8, a twin-engined helicopter, followed in 1948 by the XH-10, the largest helicopter at that time. In 1949 Kellett sold to the Hughes Aircraft Company the plans and patents relating to its 'Sky Crane', known today as the XH-17.

Barely a month after the death of W. Wallace Kellett, founder and president of the company, it seemed likely to close down because of financial difficulties. It pulled round, however, and in 1953 was awarded a contract by the United States Navy Bureau of Aeronautics to convert a Kellett autogyro into a laboratory aircraft to study the behaviour of a partially-loaded rotor system and thus provide data required for a convertiplane design.

1931 K-2

This was a two-seater side-by-side autogyro. The total weight of the four-bladed rotor was 331 pounds (150 kilos), or 22 per cent of the rotorcraft's total weight, and the blades accounted for 278 pounds (126 kilos).

The area of the low wing was 100 square feet (9·3 square metres) and the wing was made of wood.

The K-2 performed various successful demonstrations in a limited area on the Philadelphia waterfront.

Engine: Continental, 165 h.p.
Rotor diameter: 40 ft (12·19 m)
Weight empty: 1,557 lb (706 kg)
Weight fully loaded: 2,205 lb (1,000 kg)
Number of seats: 2

1932 K-3

This was an improvement on the former model by virtue of its streamlined cabin.

1933 K-4

This two-seater dual-control autogyro showed no fundamental changes from the preceding versions.

Engine: Kinner C-5, 210 h.p.
Weight empty: 1,634 lb (741 kg)
Weight fully loaded: 2,414 lb (1,095 kg)
Cruising speed: 93 m.p.h. (150 k.p.h.);
max: 112 m.p.h. (180 k.p.h.)
Number of seats: 2

1934 KD-1

The KD-1 (K standing for Kellett, D for direct control) was an open-cockpit tandem two-seater autogyro. The pylon carrying the rotor was in front of the forward seat so that there was free access to both.

The blades could be folded back so that the overall dimensions of the autogyro were reduced to 26 feet by 10 feet 3 inches by 10 feet 4 inches (7·92 by 3·12 by 3·15 metres). The landing gear was of the double fixed-tripod type.

Taken as a whole, the KD-1's performances were better than those of the British-built C-30. A number of variants were built. A KD-1A was bought in 1939 by the Japanese Air Force Testing Division, which later handed it over to the firm of Kayaba (see under Japan). The KD-1B was a variant specially designed for use by Eastern Airlines on airmail shuttle services. Finally the KD-1 was the prototype for the YG-1 military autogyro.

Engine: Jacobs L4, 225 h.p.
Length: 25 ft 10 in (7·87 m)
Width: 10 ft 4 in (3·15 m)
Height: 10 ft 3 in (3·12 m)
Rotor diameter: 40 ft (12·19 m)
Weight empty: 1,352 lb (613 kg)
Weight fully loaded: 2,052 lb (931 kg)
Cruising speed: 103 m.p.h. (166 k.p.h.)
max: 125 m.p.h. (201 k.p.h.)
min: 16 m.p.h. (26 k.p.h.)
Range: 361 miles (581 km)
Number of seats: 2

1935 YG-1

This military version of the KD-1 was tested for all types of mission at

KD-1

Wright Field, the headquarters of the United States Material Command. It was also given comparative tests against balloons for artillery fire control, night missions with flares to illuminate moving targets, etc.

This autogyro was used in two versions, YG-1A and YG-1B (YG-2 was the designation of a Pitcairn autogyro).

A YG-1B with jump take-off characteristics, powered by a 285 h.p. engine, was designated XR-2, but it was destroyed by ground resonance during testing.

The XR-3 is a modified KD-1B, using jump take-off.

Over twenty years after the first appearance of the KD-1, Kellett Aircraft again built and flew one of these machines.

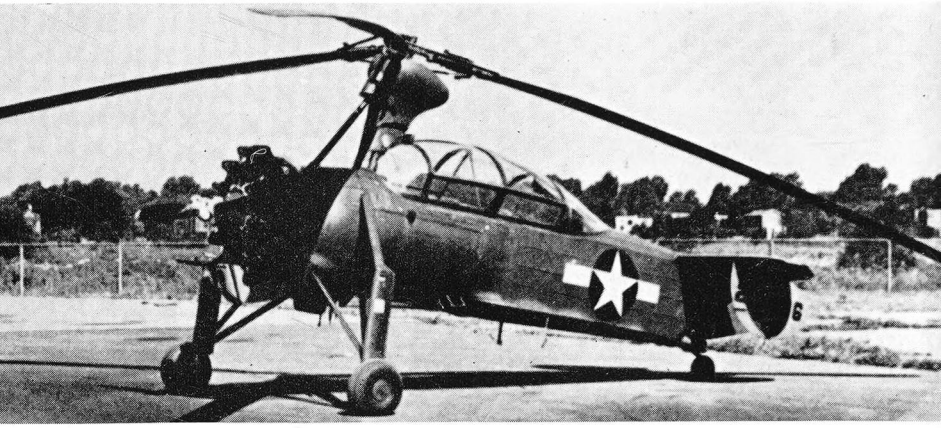
1942 YO-60

This development by Richard Prewitt of the KD-1 naturally retained the former's jump take-off feature. The YO-60 also had a large bubble-type cockpit, and since it was designed for observation duties, there were also windows in the fuselage floor.

While this autogyro was being built for the United States Army, a helicopter of a design totally different from its predecessors, the 'egg-beater' XR-8, was in the developmental stage.

Engine: Jacobs R-915-3, 300 h.p.

Length: (blades folded) 25 ft 11 in (7·9 m)
Height: 10 ft 2 in (3·1 m)
Rotor diameter: 43 ft 2 in (13·16 m)
Number of seats: 2



YO-60

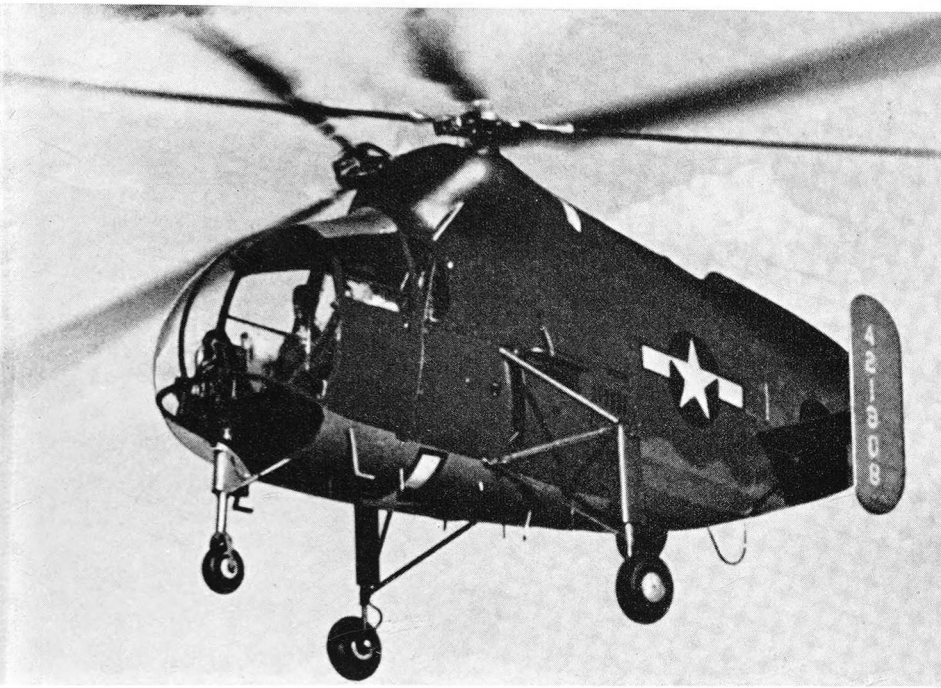
1944 XR-8

This experimental military two-seater helicopter, which first flew on 7 August 1944, differed radically from earlier Kellett designs and was nicknamed 'Synchropter' because of its two intermeshing three-bladed rotors.

This configuration, familiarly known as an 'egg-beater' and used in 1938 by the German designer Flettner for his Fl-265 (*q.v.*), first appeared in the United States on this helicopter with blades which overlapped as the rotors turned in opposite directions.

The distance between the XR-8's two hubs was 4 feet (1·22 metres), and power was directly transmitted to the rotors through pairs of bevel gears.

Engine: Franklin O-405-9, 245 h.p.
Length: (overall) 22 ft 7 in (6·88 m)
Height: 11 ft (3·35 m)
Rotor diameter: 36 ft (10·97 m)
Weight empty: 2,320 lb (1,052 kg)
Weight fully loaded: 2,975 lb (1,349 kg)
Cruising speed: 85 m.p.h. (137 k.p.h.)
max: 100 m.p.h. (161 k.p.h.)
Absolute ceiling: 7,000 ft (2,134 m)
Number of seats: 2



XR-8

1947 XH-10

When it made its first flights in April 1947 this helicopter was the largest and most powerful designed for the United States Air Force at that time. Like the XR-8, it was of the 'Synchropter' type with contra-rotating and intermeshing rotors.

The rotors were driven by two engines mounted on nacelles on either side of the fuselage so as to leave the cargo space unobstructed, and cooling was by the flow of air induced through the nacelles. Rotor-head linkage allowed the blades to pivot in the horizontal and vertical planes. In the horizontal plane, blade movements were damped by vibration dampers; the position of the blades was a function of the centrifugal force and the loading conditions, but there were, of course, stops to limit these movements. The rotors were synchronized through a cross drive between the upper transmissions.

One special feature of this XH-10 was its ability to fly on one engine with normal gross weight at altitudes of up to 4,600 feet (1,402 metres).

Engines (2)*:* Continental R-975-15, 525 h.p.

Length: 28 ft 8 in (8·74 m)
Rotor diameter: 65 ft (19·81 m)
Weight empty: 6,640 lb (3,012 kg)
Weight fully loaded: 11,000 lb (4,990 kg)
Cruising speed: 90 m.p.h. (145 k.p.h.)
max: 115 m.p.h. (185 k.p.h.)
Inclined climb: 1,500 ft/min (457 m/min)
Absolute ceiling: 15,000 ft (4,572 m)
Range: 160 miles (257 km)
Number of seats: 12

XH-10

1950 KH-2A (PROJECT)

This proposed civil version of the military XH-10 was to have had the same side-by-side intermeshing-rotor configuration with more powerful engines, again placed in nacelles on either side of the cabin so as to leave 480 cubic feet (nearly 14 cubic metres) of space available. According to the mockup which was made, there would have been room for sixteen passengers.

1954 KH-15 STABLE MABEL

This variable-stability helicopter was a flying test bed developed with the Office of Naval Research as sponsor to study the behaviour of a small helicopter in which the significant parameters of the rotor could be altered.

This single-seater was powered by two hydrogen peroxide rocket engines mounted one at each blade tip, and fuel was stored in two spherical tanks situated to the right and left of the pilot.

The fuselage was an open steel tube structure to which was attached a

fixed-tripod landing gear, the main rotor, rotor controls and an open truss boom supporting the conventional variable-pitch-type tail rotor.

This helicopter was designed to test the new gyro-stabilizing system, a kind of small rotor mounted concentrically and intended to stabilize the main rotor. This stabilizer system, developed by Dr G. J. Sissingh, should be applicable to all types of helicopter, whether having single, tandem, side-by-side or co-axial rotors. It is, furthermore, independent of the type of propulsion.

Trials were started early in 1954 to demonstrate positive dynamic stability without loss of control throughout the entire speed range, and the KH-15 in fact exhibited excellent stick-fixed dynamic stability.

Engines (2)*:* XLR-32RM rockets
Rotor diameter: 18 ft (5·49 m)
Weight fully loaded: 644 lb (292 kg)
Number of seats: 1

KH-15

LANDGRAF

In order to develop his own design ideas Fred Landgraf in 1943 incorporated the Landgraf Helicopter Corporation, of which he became President. He first built his H-2 experimental helicopter to test the ideas embodied in it as a first stage in introducing them into a large helicopter.

Towards the end of 1944 this model was ready and started to fly,

whereupon Landgraf set to work on the preliminary design of the H-3, for two or three passengers, and of the H-4, for five to eight passengers.

By 1948 the H-2's test programme was completed, but since the U.S. Air Force could not provide the credits needed to carry out the projects planned, the company's existence came to an end in 1949.

A licence for Landgraf's helicopter was granted to the British firm of Firth.

1944 H-2

This helicopter had two three-bladed wooden rotors on twin booms 11 feet (3·35 metres) apart; the rotors were synchronized and their blades overlapped. They were not hinged at the root, but their tips were fitted with ailerons which could be cyclically deflected. The ailerons could thus be in the 'up' position for a given position of the blade, and when it moved through 180 degrees, in the 'down' position. By thus changing the lift vector, the helicopter could be made to fly in any required direction. Since all steering was done through the rotors, the tail fin was rigid. The fuselage and outriggers were of plywood and of monocoque construction. Among various other features were automatic collective pitch control, centre of gravity well forward of the rotor axis to increase stability, and retractable tricycle undercarriage. Provision was made for the blades to reduce pitch in case of engine failure and thus put themselves in the auto-rotation position.

The H-2 flew for the first time on 2 November 1944.

Engine: Pobjoy R, 85 h.p.
Length: 15 ft (4·57 m)
Rotor diameter: 16 ft (4·88 m)
Weight empty: 636 lb (288 kg)
Weight fully loaded: 850 lb (386 kg)
Cruising speed: 70 m.p.h. (113 k.p.h.)
max: 85 m.p.h. (137 k.p.h.)
Range: 115 miles (185 km)
Number of seats: 1

LEINWEBER-CURTISS, 1921

Although this aircraft had virtually no success, it nevertheless embodied an original concept, which was revived after World War II by Bell and Transcendental.

In 1920–21 Leinweber, in collaboration with Curtiss, an engineer, produced this aircraft with four rotors in all, placing two on each side of the fuselage, which included the central rotating motor and also a rudder.

The two pairs of three-bladed rotors were, in theory, to tilt forward and ensure horizontal propulsion.

LIFT SYSTEMS

With Martin Jensen, who during the years which followed the last war succeeded in building two helicopters with co-axial contra-rotating rotors, some engineers of an aircraft firm developed during their spare time a light helicopter, which they hope to follow later with an executive helicopter produced within their organization, Lift Systems Inc.

1965 LS-3

A flight-control test vehicle, the LS-3 is made from a tubular steel airframe covered with glass fibre. The two-bladed rotors are made entirely of metal, and the control innovations invented by the Lift Systems team were revealed as satisfactory in the first flights.

Engine: Lycoming O-320A-2A, 150 h.p.
Fuselage length: 13 ft 7 in (4·14 m)
Width: 4 ft 3⅓ in (1·31 m)
Height: 9 ft 7½ in (2·94 m)
Rotor diameter: 27 ft (8·23 m)
Weight empty: 1,205 lb (547 kg)
Weight fully loaded: 1,600 lb (726 kg)
Cruising speed: 70 m.p.h. (113 k.p.h.)
max: 90 m.p.h. (145 k.p.h.)
Rate of climb: 1,300 ft/min (396 m/min)
Number of seats: 2

LOCKHEED

Since 1957 the Lockheed-California Company, a division of Lockheed Aircraft Corporation whose achievements in space flight are well known, has been investigating the best way to produce a light multi-purpose aircraft. Encouraged by recent progress in the VTOL field, the Company's specialists have reviewed the cost, performance, handling qualities and safety of all existing aircraft and more especially those with rotary wings. They have compared three types of rotor: the teetered, the hinged, and the rigid. The results of this work have decided them in favour of the rigid rotor coupled to a gyroscope system. The gyroscope, gimballed on top of the rotor mast, changes the pitch of the rotor blade.

In the Lockheed rigid rotor, the blades are attached rigidly to both the rotor mast and transmission and have no teetering or flapping hinges. The term non-articulated rotor would perhaps be more accurate, since the cantilever blades possess a certain flexibility along their length which allows for some flapping.

The success obtained by Lockheed in the realm of rigid-rotor compound flight means that among the research studies at Lockheed is to be

found a 30- to 95-passenger compound capable of 300 m.p.h. (483 k.p.h.) and with a 250-mile (402 km) range. Intensive research and wind-tunnel tests have been conducted on an even more advanced rigid-rotor craft that would take off like a helicopter, then fold back and contract its blades and continue as a fixed-wing aircraft at speeds of up to 500 m.p.h. (805 k.p.h.).

1959 CL-475

After free flight and wind-tunnel tests with models, Lockheed decided to produce a rigid-rotor test vehicle known as the CL-475. The three rotor blades are cantilevered from the hub and can therefore rotate only in cyclic pitch. A larger ring about $4\frac{1}{2}$ feet (1·37 metres) in diameter is placed just above the fuselage and below the rotor. It turns with the rotor and through its three arms extending to each of the blades constitutes the gyroscope stabilization system.

The maiden flight took place in November 1959 at Rosamund dry lake.

Engine: Lycoming, 140 h.p.
Height: 9 ft 3 in (2·82 m)
Rotor diameter: 32 ft (9·75 m)
Weight empty: 1,625 lb (737 kg)
Weight fully loaded: 2,000 lb (907 kg)
Maximum speed: 90 m.p.h. (145 k.p.h.)
Ceiling in ground effect: 2,000 ft (610 m)
Range: 75 miles (121 km)
Number of seats: 2

1962 CL-595, XH-51A AEROGYRO

Satisfactory tests with the CL-475 led to a joint Army-Navy contract for a rigid-rotor research helicopter. The two prototypes built resembled the CL-475 in having gyroscope control to ensure improved stability performance. On the XH-51A the gyroscope is mounted above the rotor and has arms with weights attached at their tips.

Engine: UAC (Pratt and Whitney) PT6B-9, 550 s.h.p.
Length: (fuselage) 32 ft (9·75 m)
Height: 9 ft (2·74 m)
Rotor diameter: 35 ft (10·67 m)
Weight empty: 2,640 lb (1,197 kg)
Weight fully loaded: 4,000 lb (1,814 kg)
Cruising speed: 160 m.p.h. (257 k.p.h.)
max: 174 m.p.h. (280 k.p.h.)
Inclined climb: 1,800 ft/min (549 m/min)
Ceiling in ground effect: 10,000 ft (3,048 m)
Range: 350 miles (563 km)
Number of seats: 2

XH-51A COMPOUND

1964 XH-51A COMPOUND

This is a four-bladed XH-51A converted from pure to compound helicopter by the addition of 17-foot (5·18-metre) span stub wings and a Pratt and Whitney J60-P-2 jet engine mounted on the left wing. This high-speed research vehicle flew at 272 m.p.h. (438 k.p.h.) during 1965 as part of a programme sponsored by the U.S. Army.

Engine: UAC (Pratt and Whitney) PT6B-9, 550 s.h.p., plus P & W J60-P-2
Rotor diameter: 35 ft (10·67 m)
Weight empty: 3,620 lb (1,642 kg)
Weight fully loaded: 4,500 lb (2,041 kg)
Number of seats: 1

1964 XH-51N

This two-seater, three-bladed-rotor pure helicopter, closely resembling the XH-51A, was built in 1964 for the National Aeronautics and Space Administration to carry out additional research on rotary-wing aircraft. Like its predecessors, it has as power-plant a turbine engine produced by United Aircraft of Canada and its maximum speed is 174 m.p.h. (280 k.p.h.).

1965 MODEL 286

Closely related to the XH-51 except that it has 5 seats, this machine is provided with a four-bladed rigid rotor. It has succeeded in attaining a

speed of 206 m.p.h. (332 k.p.h.) and was the first rigid-rotor helicopter to be certified by the Federal Aviation Agency in June 1966. Its primary mission is as a rigid-rotor demonstrator.

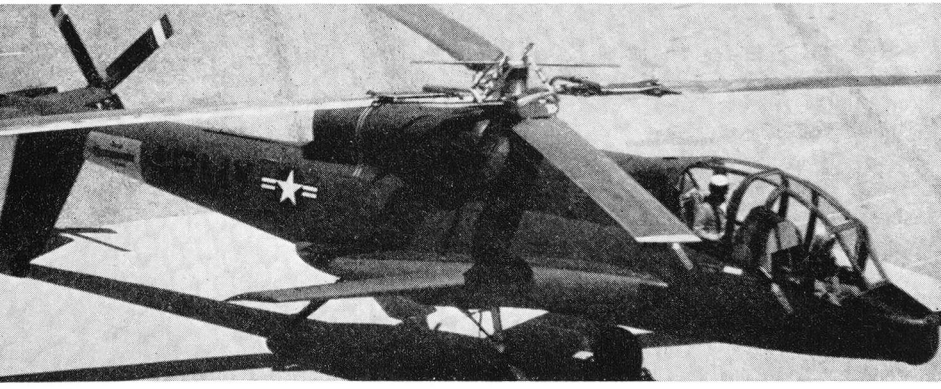
Engine: UAC (Pratt and Whitney) PT6B-9, 550 s.h.p.
Fuselage length: 32 ft (9·75 m)
width: 7 ft (2·13 m)
height: 8 ft (2·44 m)
Rotor diameter: 35 ft (10·67 m)
Weight empty: 2,815 lb (1,277 kg)
Weight fully loaded: 4,700 lb (2,132 kg)
Cruising speed: 155 m.p.h. (249 k.p.h.)
Rate of climb: 1,650 ft/min (503 m/min)
Service ceiling: 14,000 ft (4,267 m)
Number of seats: 5

1966 AH-56A CHEYENNE

At the end of 1965 this rotorcraft, developed at Lockheed's Van Nuys, California plant, won the AAFSS (Advanced Aerial Fire Support System) design competition. It is fitted with fixed wings as well as a triple-bladed rear pusher propeller of 10-foot (3-metre) diameter and, on the left of the horizontal stabilization plane, with a small anti-torque rotor of the same diameter. The pilot and co-pilot/gunner are seated in tandem.

The first eight prototypes have been assigned to various tests: armament, avionics, systems, etc. This craft first flew in public on 12 December 1967. The following January, the U.S. Army placed an important order for this machine as an escort and troop-carrying helicopter. This order was cancelled in 1969.

Engine: General Electric T64-GE-16, 3,400 s.h.p.



AH-56A

Length: 54 ft 8½ in (16·67 m)
Width: 26 ft 8½ in (8·14 m)
Height: 13 ft 8½ in (4·18 m)
Rotor diameter: (main) 50 ft 4 in (50·34 m)
Weight fully loaded: 16,990 lb (7,707 kg)
Weight empty: 11,718 lb (5,315 kg)
Cruising speed: 241 m.p.h. (388 k.p.h.)
max: 253 m.p.h. (407 k.p.h.)
Rate of climb: 3,420 ft/min (1,042 m/min)
Service ceiling: 25,000 ft (7,620 m)
Number of seats: 2

LOGAN

Frank Logan, who works for an aircraft firm, has, since 1959, designed and then constructed a little single-seater 'amateur' helicopter, which was completed in 1966.

1959 LOGAN PIXIE

The engine is placed horizontally and the helicopter is built of light alloy and glass fibre.

Engine: Continental, 65 h.p.
Length: (overall) 18 ft (5·49 m)
Rotor diameter: 21 ft (6·4 m)
Weight empty: 550 lb (249 kg)
Cruising speed: 70 m.p.h. (113 k.p.h.)
Number of seats: 1

McCULLOCH

The McCulloch Motors Corporation, which is a mass-production manufacturer of gas engines, set up its own Helicopter Division in 1949 on the completion of a helicopter known as the MC-4.

The latter was a development of the 1947 experimental tandem-rotor helicopter designed by D. K. Jovanovich and Frank Kozloski, who were respectively McCulloch's chief design consultant and engineering consultant (see under Jovair).

1951 MC-4 (YH-30)

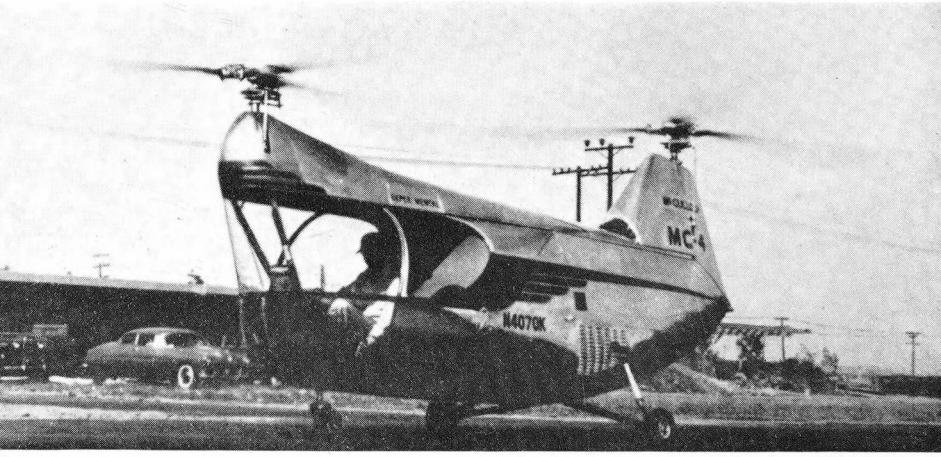
This development of the JOV-3 was fitted with tandem-mounted, intermeshing three-bladed rotors. The rear one of these is slightly above the other, which in horizontal flight lessens the downwash effect of the front rotor.

The engine, of standard air-cooled horizontal type, operated a horizontal main shaft located in the upper fuselage, by means of a vee-belt central drive. The main shaft operated the rotors by means of right-angle reduction gear units.

The tricycle landing gear was fitted with a fully swivelling nose wheel.

The U.S. Army designation was YH-30, and three of these helicopters were delivered for evaluation.

Engine: Franklin 6A4-200-C6, 200 h.p.
Length: (overall) 32 ft 5 in (9·88 m)
Height: 9 ft 1 in (2·77 m)
Rotor diameter: 23 ft (7·01 m)
Weight empty: 1,600 lb (726 kg)
Weight fully loaded: 2,300 lb (1,043 kg)
Cruising speed: 85 m.p.h. (136 k.p.h.)
max: 105 m.p.h. (169 k.p.h.)
Service ceiling: 10,000 ft (3,048 m)
Range: 200 miles at 75 m.p.h. (322 km at 121 k.p.h.)
Number of seats: 2



MC-4

McDONNELL

The engineering company of J. S. McDonnell and Associates was set up in 1928 to build an aircraft 'within everyone's reach'. As a result the 'Doodlebug' was entered for the Guggenheim Safe Airplane Competition, but during its test flights it unfortunately met with various accidents.

Starting in 1933, McDonnell worked for six years with Glenn L. Martin, and then in 1939 founded his own firm, the McDonnell Aircraft Corporation (MAC). In 1940 orders were obtained for aircraft parts from Douglas, Lockheed and Boeing; when jet engines came into use, MAC specialized in producing jet aircraft for the U.S. Navy.

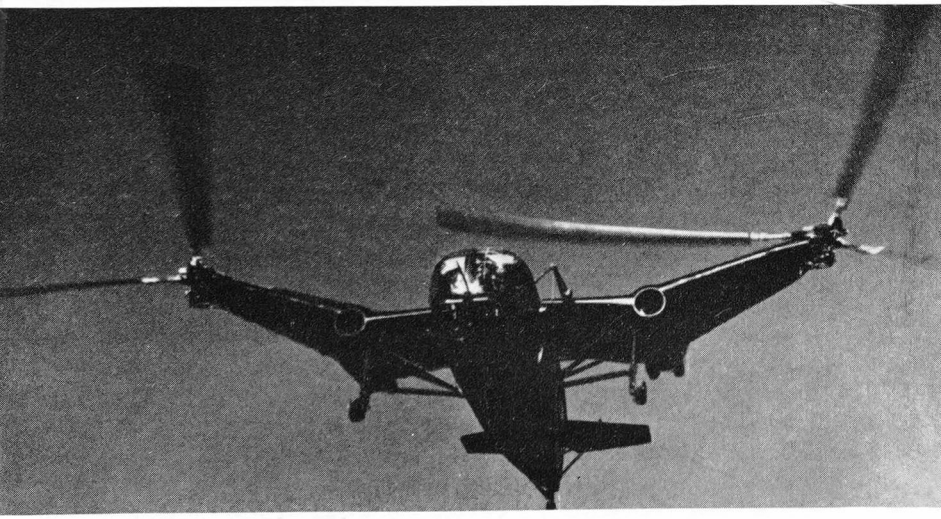
At the end of World War II the firm concerned itself with rotary wings and did developmental work on an aircraft of the same lineage as the Platt LePage XR-1, a large helicopter with side-by-side rotors, suitable for utility and sea rescue work by the U.S. Navy.

Later, Hohenemser, one of Germany's leading helicopter scientists, and Doblhoff, who had designed the first jet helicopter to have flown successfully (1943), joined McDonnell's staff, and the XV-1 convertiplane was built.

Among various MAC projects were the Model 78 (XHRH-1), a marine helicopter with a gas-turbine, and Model 86 (XHCH-1), a gas-turbine flying crane.

1946 XHJD-1 WHIRLAWAY

This experimental aircraft, the development of which was closely followed by C. Zakhartchenko, chief engineer of the MAC Helicopter Division, was finished in 1946, and has since been used for numerous flying research tests with, for example, rotors of varying diameters. These tests have proved the effectiveness of the outstanding design feature: twin side-by-side three-bladed rotors, mounted on pylons extending outboard



XHJD-1

from the engine nacelles and carrying 20 per cent of the gross weight at cruising speed. The rear part of the helicopter resembles a typical fixed-wing aircraft with a vertical tail and horizontal stabilizer.

Model 65 is the proposed commercial version fitted with two Wright C-7 B-5 engines.

Engines (2): Pratt and Whitney R-985-AN-14B, 450 h.p. each
Rotor diameter: 46 ft (14·02 m)
Weight empty: 8,000 lb (3,629 kg)
Weight fully loaded: 11,000 lb (4,990 kg)
Cruising speed: 90 m.p.h. (145 k.p.h.)
max: 120 m.p.h. (193 k.p.h.)
Inclined climb: 1,300 ft/min (396 m/min)
Absolute ceiling: 12,900 ft (3,932 m)
Range: 300 miles (483 km)
Number of seats: 10

XHJD-1

1947 MODEL 38 (XH-20 LITTLE HENRY)

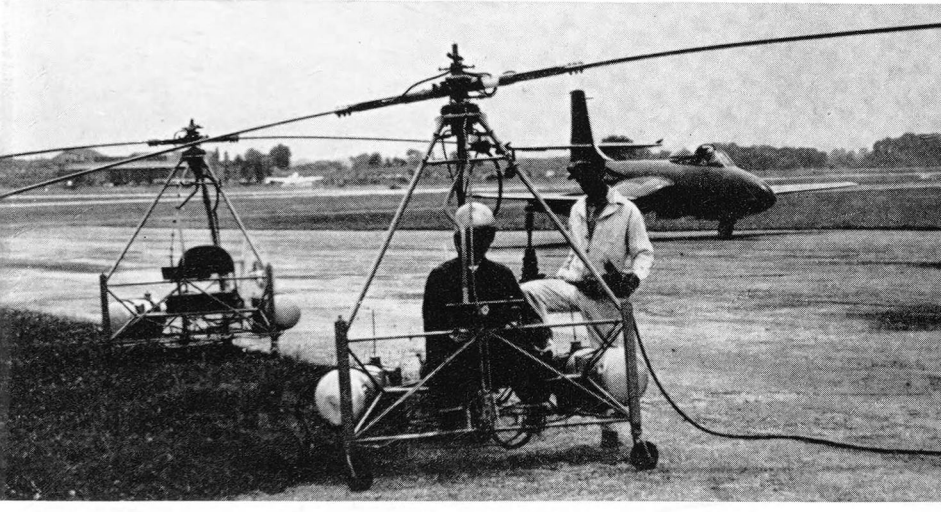
This prototype is a single-seater, and the two blades of its rotor carry at their tip a ram-jet which develops about 30 h.p. The rotor itself is of the direct tilting see-saw type; the mechanical parts do not provide for cyclic variation.

The ram-jets are run on propane, which is preheated before being ducted to them. High fuel consumption considerably reduces the aircraft's range even though the rotor's high rate of 640 r.p.m. results in good yields from the ram-jets.

The body is of welded tubes carried on three vertical legs, which can be elastically extended and end in wheels free on their axis.

XH-20 is the U.S. Air Force designation of this prototype.

Engines (2)*:* McDonnell $7\frac{1}{4}$-in ram-jets
Rotor diameter: 18 ft (5·49 m)
Weight empty: 285 lb (129 kg)
Weight fully loaded: 560 lb (254 kg)
Cruising speed: 50 m.p.h. (80 k.p.h.)
Number of seats: 1



XH-20

1954 MODEL 82 (XV-1)

This convertiplane, which works on the 'unloaded rotor' principle, was a joint development by McDonnell, the U.S. Air Force's Air Research and Development Command and the U.S. Army's Transport Corps. The McDonnell designers were Hohenemser and Doblhoff.

The XV-1 has a reciprocating engine placed aft on the fuselage which acts by feeding air through tubes to small pressure jets at the tips of the three-bladed rotor during vertical flight. These pressure jets operate on the principle of ignition and expansion of the fuel gases.

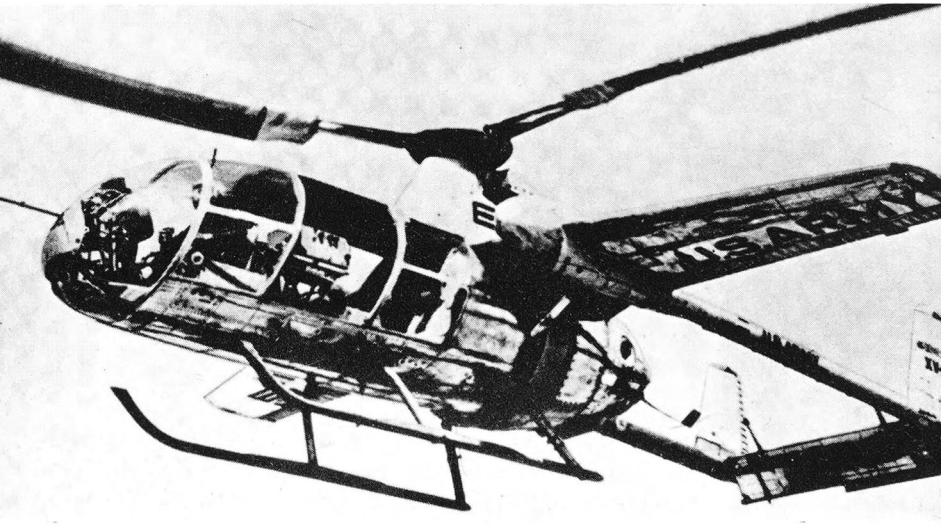
In forward flight the pilot uses the convertiplane as a helicopter until he exceeds the stalled speed of the aircraft's wings. Power is then transferred from rotor to airscrew, and flight control from rotor to aircraft. The rotor then turns by auto-rotation while the small airscrew sited between the twin tail booms comes into action.

Normally, pilot and co-pilot sit in tandem with removable dual control. With a single pilot, three passengers or two stretchers can be carried. The landing gear consists of two non-retractable skids.

The first switch-over from helicopter to fixed-wing flight took place on 29 April 1955.

During the development work, in order to check the tip burners (familiarly known as 'cans' at McDonnell's), a special whirl stand was built to provide both shaft and air power respectively from a Pratt and Whitney engine and a modified Westinghouse turbojet, which gave air drive.

Engine: Continental R-975-19, 550 h.p.
Length: 30 ft (9·14 m)
Height: 10 ft (3·05 m)
Number of seats: 4



XV-1

1952 MODEL 78 (XHRH-1)

This project for a large assault helicopter powered by a gas-turbine and intended for use by the United States Marine Corps was started in 1952.

1953 MODEL 86 (XHCH-1)

This project for a 'flying crane' making use of the McDonnell tip drive was intended for service with the United States Marine Corps.

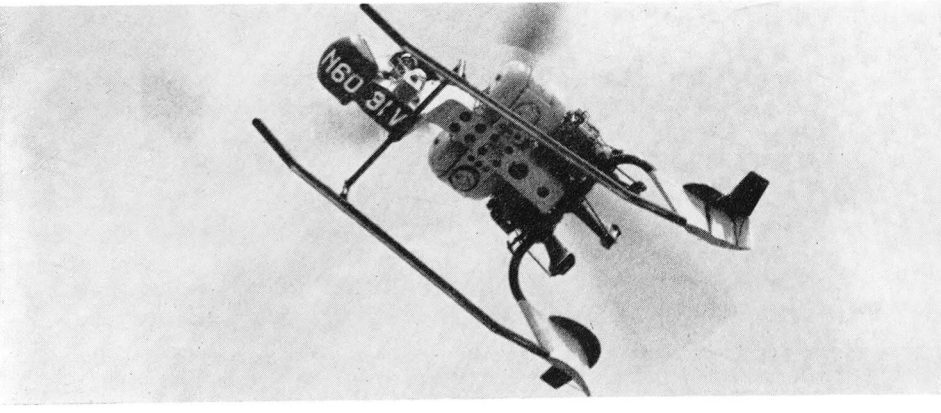
1958 MODEL 120

This utility cargo helicopter uses three gas-turbine compressors to feed compressed air ducted through the hub blade spars into pressure jet burners mounted on each of the three rotor blade tips—the principle developed on the XV-1 Army convertiplane.

In the absence of any requirement to provide space and structure for a transmission system, the power shafting and tail rotor have given this rotorcraft a fuselage configuration with an unobstructed cargo space situated immediately below the centre of gravity.

This experimental aircraft, which flew for the first time in 1958, can be made into a fire-fighter, armament carrier or personnel transport, using a kit consisting of two toboggan-type seats and fibreglass shields to protect the twelve occupants. It can also be made into a flying crane. In fact, a maximum-load to empty-weight ratio of 1·5 : 1 was achieved during trials.

Engines (3): AiResearch GTC-85-36
Length: 20 ft (6·1 m)
Height: 9 ft (2·74 m)
Rotor diameter: 31 ft (9·45 m)
Weight empty: 2,450 lb (1,111 kg)
Weight fully loaded: 5,000 lb (2,268 kg)
Cruising speed: 109 m.p.h. (175 k.p.h.)
max: 138 m.p.h. (222 k.p.h.)
Inclined climb: 2,400 ft/min (749 m/min)
Ceiling: (in ground effect) 12,000 ft (3,658 m)
Range: 98 miles (158 km)
Number of seats: 1



MODEL 120

MARQUARDT

The Marquardt Company was set up in 1944 for the purpose of study work into subsonic ram-jet engines. The company has since developed 20-inch (50·8-centimetre) diameter ram-jets capable of supplying power equivalent to 2,500 h.p. A Lockheed F-80 Shooting Star fixed-wing aircraft was fitted with this ram-jet and during trial flights was powered solely by it, the normal power source having been switched off.

Development work has also been done on other ram-jet engines as well as on pulse-jet engines to equip target drones.

Marquardt has also produced a helicopter powered by two pulse-jet engines 8 inches (20·3 centimetres) in diameter.

1948 M-14

This helicopter, a simplified structure in steel tubing, was intended to act as a flying test bed for the pulse-jet engines developed by the Marquardt Company. At each tip of the two-bladed rotor were located the above-mentioned pulse-jet engines. Directional control was ensured by means of a rudder.

The M-14 was the first American helicopter to have flown on power provided by two pulse-jet engines.

Engines (2)*:* pulse-jets, 8 in (20·3 cm) in diameter
Rotor diameter: 29 ft (8·84 m)
Weight empty: 800 lb (363 kg)
Weight fully loaded: 1,200 lb (544 kg)
Cruising speed: 65 m.p.h. (105 k.p.h.)
Number of seats: 1

MONTE-COPTER

Since 1955 Monte-Copter Inc. of Seattle has been engaged on developing a helicopter from which it has since designed prototypes operating on air generators.

1956 MODEL 10

This helicopter is fitted with fixed wings intended to off-load the rotor and with a tail boom having twin fins.

The rotor is two-bladed with servo-control devices mounted at 90 degrees to the blades. Power comes from a piston engine driving a centrifugal compressor.

Engine: Lycoming, O-290-B2
Rotor diameter: 32 ft (9·75 m)
Number of seats: 2

1957 MODEL 10A

This is a Model 10 modified by removing the cabin skin and the wings and by replacing the piston engine with two Continental Model 140 (Turboméca) air compressors mounted on each side of the fuselage and feeding the two-bladed rotor at the blade tips. The helicopter also has twin fins.

1958 MODEL 12

This model is a Model 10 equipped with two turbines and with a modified tail having a single rudder placed in the jet efflux. The rotor is still of the same type with two blades and a cold-cycle pressure-jet.

1960 MODEL 15 TRIPHIBIAN

This compact helicopter works on the same principle as its predecessors. It is an amphibian aircraft possessing small delta-shaped wings with fuel tanks at their tips to ensure stability on water. The efflux from the turbocompressor provides facilities for taxiing on land or water.

Engine: Continental 141, 200 h.p.
Length: (fuselage) 15 ft 3 in (4·65 m)
Height: 8 ft 3 in (2·51 m)
Rotor diameter: 36 ft (10·97 m)
Weight unloaded: 1,232 lb (559 kg)
Weight fully loaded: 2,000 lb (907 kg)
Cruising speed: 75 m.p.h. (121 k.p.h.)
Inclined climb: 1,100 ft/min (335 m/min)
Range: 100 miles (161 km)
Number of seats: 3

NAGLER

Bruno Nagler, whose earliest rotary-wing experiments go back to 1929 (see under Austria), emigrated to the United States in 1952.

There he has built various prototypes, all single-seaters like his former designs, but with a totally different concept of an anti-torque rotor in the extension of the main rotor.

1952 XNH-1 HELIGLIDER

This, the first rotorcraft which Nagler designed after his arrival in the United States, was of the 'strap-on' variety.

Its intended use was to cross rivers or other obstacles. The required height was to be reached by power from six solid-propellent rockets, fired in pairs and providing a 20-pound (9-kilo) thrust for about twenty seconds.

Slow descent was ensured by the auto-rotation of the rotor. The six rockets could be replaced for later use.

The wearer's legs were to be the landing gear.

Engines (6)*:* 20-lb (9-kg) rockets
Weight empty: 65 lb (29 kg)
Number of seats: 1

1954 CONVERTOCRAFT 130

This convertiplane consisted of an Aeronca fuselage minus the wings and plus a two-bladed rotor powered by six solid-fuel rockets placed three at the tip of each blade and each providing a 90–150-pound (41–68-kilo) thrust. The airscrew used for forward flight was powered by a Continental reciprocating engine. After the rocket power take-off, the Convertocraft flew forward with the rotor freewheeling.

Engine: Continental, and 6 rockets
Rotor diameter: 30 ft (9·14 m)
Weight fully loaded: 1,450 lb (658 kg)
Cruising speed: 80 m.p.h. (129 k.p.h.)
Number of seats: 2

1954 NH-120

This ultra-light single-seater has two rotors: one main rotor with collective and cyclic pitch control, the latter by a hanging stick, and one smaller anti-torque rotor. Nagler's ingenuity in this design consists in placing the latter above the main rotor, which is thus surmounted by the driving engine directly above it and a two-bladed, much smaller diameter fixed-pitch rotor. This compact unit, two rotors with the engine between them, is supported by the helicopter frame made of tubes and containing the pilot's seat with fuel tanks behind it. The 45 h.p. engine originally planned for proved insufficiently powerful and has been replaced. The tricycle landing gear has three wheels held at the end of legs fitted with shock absorbers.

When folded this rotorcraft will go into a container measuring 2 feet 6 inches by 7 feet (76 by 213 centimetres).

Engine: McCulloch, 70 h.p.
Height: 9 ft (2·74 m)
Rotor diameter: upper: 7 ft (2·13 m)
lower: 19 ft 11¾ in (6·09 m)
Weight empty: 280 lb (127 kg)
Weight fully loaded: 750 lb (340 kg)
Cruising speed: 62 m.p.h. (100 k.p.h.)
max: 73 m.p.h. (117 k.p.h.)
Range: 80 miles (129 km)
Number of seats: 1

1956 NH-160

This later version incorporates the lessons learnt from the NH-120, and while the general principle remains the same, i.e. the main rotor in the same alignment as the anti-torque rotor, their positions have been changed.

The two-bladed main rotor remains in its usual position, but the anti-torque rotor with three articulated blades is on the helicopter's underside between the two skis acting as landing gear, and 6 feet (1·83 metres) away from the main rotor. The latter has cyclic and collective control and is mounted on an oscillating hub. In horizontal flight it turns at 400 r.p.m. and the lower rotor at 1,500 r.p.m., the latter consuming 55 h.p., the former 15 h.p. of the engine's total power.

Nagler has designed an unusual steering system: two disc brakes of the kind used in motor vehicles, one acting on the main rotor, the other on the shaft of the engine to which the anti-torque rotor is fixed. These brakes are pedal-operated.

A fixed vertical surface at the end of the rudimentary fuselage ensures directional stability.

The production model was planned to have an enclosed cockpit and fuselage.

Engine: McCulloch 4-318, 70 h.p.
Length: 12 ft (3·66 m)
Width: 9 ft 6 in (2·9 m)
Rotor diameter: upper: 19 ft $11\frac{3}{4}$ in (6·09 m)
lower: 7 ft (2·13 m)
Weight empty: 420 lb (191 kg)
Weight fully loaded: 880 lb (399 kg)
Cruising speed: (max.) 120 m.p.h. (193 k.p.h.)
Number of seats: 1

1963 VG-1 VERTIGYRO

The Vertigyro prototype consists of a Piper Colt fuselage minus wings and of a Djinn-type rotor, which, driven by compressed air, enables the aircraft to take off vertically and reach a height where the propeller is used for translation so that the Vertigyro can then fly as an autogyro. The Piper Colt engine driving the tractive propeller has been retained and the baggage hold removed to take a generator supplying compressed air to the rotor placed on a pylon some 2 feet (61 centimetres) above the top of the fuselage.

During tests the aircraft flew at a speed of 74·5 m.p.h. (120 k.p.h.) as a pure helicopter, at 90 m.p.h. (145 k.p.h.) as an autogyro and at 110 m.p.h. (177 k.p.h.) in both its roles, i.e. using the tractive power of the engine and the rotor to provide lift.

Engine: Lycoming O-235, with a Garrett Compressor

Length: 20 ft (6·1 m)
Width: 6 ft (1·83 m)
Height: 9 ft (2·74 m)
Rotor diameter: 36 ft 1 in (11 m)
Weight fully loaded: 1,735 lb (787 kg)
Cruising speed: 85 m.p.h. (137 k.p.h.)
Number of seats: 2

1964 VG-2

This is a VG-1 completely redesigned in the helicopter tradition, i.e. with a forward cabin ensuring good visibility. The engine driving the pusher propeller is mounted behind the rotor pylon.

Engine: Franklin O-325, with a BMW Compressor
Length: 18 ft (5·49 m)
Width: 6 ft 3 in (1·9 m)
Height: 8 ft (2·44 m)
Rotor diameter: 36 ft 1 in (11 m)
Weight empty: 1,050 lb (476 kg)
Weight fully loaded: 1,650 lb (748 kg)
Cruising speed: 110 m.p.h. (177 k.p.h.)
Number of seats: 2

NEMETH

The Nemeth Helicopter Corporation produced a helicopter designed by Stephen P. Nemeth.

The latter's experience in the rotary-wing field went back to the start of the inter-war period, from which time until the 1930s he was engaged in testing cyclogyros. These aircraft had rotors set laterally on a tubular frame and powered by a rotary engine.

In addition, Nemeth had carried out experimental work not only on cyclogyros but also on circular-wing aircraft, aircraft with tandem wings, etc.

1948 NEMETH

The Nemeth helicopter had a two-bladed main rotor and a two-bladed tail rotor. Just in front of the latter and below the fuselage there was a vertical stabilizer.

The fuselage itself consisted of an uncovered tubular frame. There was a two-wheel undercarriage as well as nose and tail skids.

Engine: ram-jets
Rotor diameter: 26 ft (7·92 m)
Weight empty: 220 lb (99.8 kg)

Weight fully loaded: 551 lb (250 kg)
Cruising speed: 84 m.p.h. (135 k.p.h.)
Range: 250 miles (402 km)
Number of seats: 2

OMEGA

The Omega Aircraft Corporation is headed by Bernard Sznycer, who designed the SG-VI, built and tested in Canada by the Intercity Airlines Company (see under Canada) during 1946–7, and later taken over as a prototype by the United States firm, Canamerican. Later, Omega was reorganized and became a subsidiary of the Aero Industries Inc. group of Boyertown, Pennsylvania.

The Omega prototype, though resembling the SG-VI in its rough-and-ready appearance, in other respects differed considerably from it.

1955 BS-12, 12A, 12C, 12D-1

Sznycer began design work in 1952 on this four-seater helicopter, the purpose of which was to pick up or set down heavy loads in the most inaccessible places.

The four-bladed rotor was made up of two fully-articulated two-bladed parts, one just above the other at 90 degrees to the rotor shaft, and with friction dampers on each hub arm. To increase accessibility, the two engines are located externally on each side of the frame. The landing gear has an 11-foot 9-inch (3·58-metre) tread, large enough to accommodate a small car.

This helicopter has three outstanding features: rough-and-ready appearance, ease of maintenance, and the large space provided for payloads.

Since this rotorcraft's maiden flight on 29 December 1956, it has undergone several changes, particularly in its power-plant.

The two Franklin 200 h.p. engines on the BS-12 were replaced on the BS-12A by two Franklin 210 h.p. and on the BS-12C by two Franklin 215 h.p. supercharged engines.

The BS-12D-1, a version powered by two Lycoming O-540-FIB5 engines, was FAA Type-Certificated in 1961.

Engines (2): (BS-12) Franklin 6A4-200-06, 200 h.p.
(BS-12A) Franklin, 210 h.p.
(BS-12C) Franklin, 215 h.p. supercharged
(BS-12D-1) Lycoming O-540-FIB5
Length: 36 ft 6 in (11·13 m)
Width: 4 ft 4 in (1·32 m)
Height: 13 ft (3·96 m)

Rotor diameter: 39 ft (11·89 m)
Weight empty: 2,950 lb (1,338 kg)
Weight fully loaded: 4,300 lb (1,950 kg)
Cruising speed: 86 m.p.h. (138 k.p.h.)
Inclined climb: 1,170 ft/min (357 m/min)
Service ceiling: 11,600 ft (3,536 m)
Range: 160 miles (257 km)
Number of seats: 5

BS-12

1963 BS-12D-3S

This is the fourth Omega prototype. Using the same airframe and rotor design as the BS-12D-1, it is powered by two supercharged Franklin engines delivering a maximum of 260 h.p. up to 10,000 feet (3,048 metres). The co-ordinating mechanism for the two engines operates in such a way that torque response is constant throughout the collective stick range. This helicopter can carry a payload of 1,400 pounds (635 kilos) in a pod over a distance of about 25 miles (40 kilometres).

Engines (2)*:* Franklin 6AS-335, 260 h.p.
Height: 13 ft (3·96 m)
Rotor diameter: 39 ft (11·89 m)
Weight empty: 3,350 lb (1,520 kg)
Weight fully loaded: 5,100 lb (2,313 kg)
Inclined climb: 1,100 ft/min (335 m/min)
Service ceiling: 11,500 ft (3,505 m)
Range: 175 miles (282 km)
Number of seats: 5

PIASECKI

Immediately after graduation Frank Nicholas Piasecki first worked as a mechanic with Kellett Aircraft Corporation, then as mechanical designer at the National Machine Company, and finally with the Platt LePage Aircraft Corporation, before he founded his 'Forum' of young engineering enthusiasts for rotary-wing aircraft.

The outcome of the efforts by the experts whom Piasecki had brought together was the PV-2 helicopter, which made its earliest flights in the spring of 1943 and led to the setting-up of the PV (P for Piasecki, V for Venzi) Engineering Forum. In 1944 the new firm signed a contract to design and build an experimental helicopter for the U.S. Navy.

Thirteen months later, in March 1945, the PV-3 flew successfully. Then, early in 1946, against competition from the major helicopter manufacturers, Piasecki won a contract from the U.S. Navy for his PD-14 design, the XHJP-1. During that year the company expanded and with new capital from Laurence Rockefeller and Felix Dupont Jr., changed its name to the Piasecki Helicopter Corporation. It continued to devote itself solely to the production of two-rotor helicopters in tandem configuration.

The Rockefeller group's influence increased and in 1955 Piasecki himself was removed from the board chairmanship of the corporation bearing his name. He thereupon formed a new company, the Piasecki Aircraft Corporation (*q.v.* below), and the former Piasecki Helicopter Corporation was transformed into the Vertol Aircraft Corporation ('Vertol' being the concertina form of 'vertical take-off and landing'), for which see under Vertol.

According to Piasecki himself, the objects of his new company included 'just about everything in the vertical lift aircraft field short of bullets and balloons'. It took up several projects, including a VTOL aircraft, an ultra-large flying crane, etc.

Vertol, on the other hand, was engaged in producing and improving rotorcraft developed by the Piasecki Helicopter Corporation and was simultaneously working on a contract with the U.S. Office of Naval Research and with the U.S. Army for the development of a tilting-wing aircraft. During 1960 the Vertol Aircraft Company became a division of Boeing Airplane Company.

The following list shows the development by family of the various Piasecki projects up to the formation of Vertol:

PV-2 single rotor

PV-3 leading to XHRP-X, XHRP-1, HRP-1 'banana' tandem

PD-17 leading to HRP-2

PD-22 leading to H-21; and the PH-42 leading to H-21A, B and C

PD-14 leading to XHJP-1 straight tandem

PD-18 leading to HUP-1, HUP-2, HUP-3, H-25
PV-15 leading to YH-16 prototype

The various Piasecki helicopters and their users are:

PV-2	Prototype	
PV-3	XHRP-X Dog Ship	U.S. Navy
	XHRP-1	U.S. Navy
	HRP-1	U.S. Navy
PD-14	XHJP-1	U.S. Navy
PV-15	YH-16 Transporter	U.S. Air Force
	YH-16A & B Turbotransporter	U.S. Air Force
PD-17	HRP-2	U.S. Marines
PD-18	HUP-1 Retriever	U.S. Navy
	UH-25A (H-25A) Army Mule	U.S. Army
	UH-25B (HUP-2) Retriever	U.S. Navy, French Navy
	UH-25C (HUP-3) Retriever	Royal Canadian Navy
PD-22	YH-21 Work Horse	U.S. Air Force

1943 PV-2

This prototype, developed by the PV Engineering Forum, a group consisting of Piasecki, Venzi and Daland, was a single-seater helicopter with a three-bladed rotor, obviously having cyclic pitch control. Two blades could be folded back when space had to be saved for storage in a hangar. There was also a tail rotor 5 feet (1·52 metres) in diameter. The main rotor was driven by a 4-cylinder air-cooled engine mounted with its crankshaft upright. The fabric-covered fuselage was designed to provide the pilot with excellent visibility.

The PV-2 was shown publicly on many occasions by Piasecki, the first American ever to be granted a helicopter pilot's licence.

This rotorcraft, the first of the Piasecki series, was the only one to have a single main rotor and an anti-torque tail rotor.

Engine: Franklin, 90 h.p.
Length: (2 blades folded) 22 ft (6·71 m)
Width: 8 ft (2·44 m)
Height: 7 ft 7 in (2·31 m)
Rotor diameter: 25 ft (7·62 m)
Weight fully loaded: 1,000 lb (454 kg)
Cruising speed: 65 m.p.h. (105 k.p.h.)
Number of seats: 1

1945 PV-3 (HRP-1) RESCUER

The various prototypes resulting from developmental work were respectively known as XHRP-X, XHRP-1 and HRP-1, the latter frequently nicknamed the 'Flying Banana'. This model has been produced in large numbers.

PV-2

All the above had two rotors in tandem configuration, to which engine torque was transmitted through a clutch assembly and a gearbox amidships. From there it was transmitted by means of driveshafting to reduction gearboxes located below each rotor hub.

This helicopter provided ten seats in a cabin with a cubic capacity of roughly 400 cubic feet (just over 11 cubic metres), and its basic duties were rescue work and the transport of passengers or freight.

Engine: Pratt and Whitney R-1340-AN-1, 600 h.p.
Length: (fuselage) 47 ft 2 in (14·38 m)
Height: 13 ft 11 in (4·24 m)
Rotor diameter (2)*:* 41 ft (12·5 m)
Weight empty: 5,041 lb (2,287 kg)
Weight fully loaded: 6,900 lb (3,130 kg)
Cruising speed: 80 m.p.h. (129 k.p.h.)
max: 100 m.p.h. (161 k.p.h.)
optimal: 60 m.p.h. (97 k.p.h.)
Inclined climb: 950 ft/min (290 m/min)
Absolute ceiling: 10,400 ft (3,170 m)
Range: 265 miles (426 km)
Number of seats: 10

1948 PD-17 (HRP-2)

This helicopter, which is at present out of production, was intended

HRP-2

primarily for rescue work and as a personnel and general-purpose transport.

This version showed various improvements over its predecessor: it was of stressed skin construction and had a semi-monocoque fuselage, with access to the cabin compartment by a sliding door. The more rigid fuselage structure considerably reduced vibration, and visibility was better under all flight conditions.

Engine: Pratt and Whitney 1340-AN-1, 600 h.p.
Length: (fuselage) 54 ft (16·46 m)
Height: (fuselage) 14 ft (4·27 m)
Rotor diameter: 41 ft (12·5 m)
Weight empty: 5,301 lb (2,404 kg)
Weight fully loaded: 7,225 lb (3,277 kg)
Cruising speed: 85 m.p.h. (137 k.p.h.)
Inclined climb: 900 ft/min (274 m/min)
Absolute ceiling: 10,000 ft (3,048 m)
Range: 287 miles (462 km)
Number of seats: 10

1952 PD-22 (H-21) and PH-42 (H-21A, H-21B, H-21C) WORK HORSE

There are four versions of the H-21, which is itself an extrapolation of the HRP design. The prototype PD-22 was evaluated as the H-21, and the production model 42 led to the H-21A, B and C. The PH-42 civilian version can carry nineteen passengers, together with their luggage

and a load of mail in a detachable 'helipac' of some 80 cubic feet (slightly over 2 cubic metres). An alternative model designed for freight transport has cargo space of 615 cubic feet (17·4 cubic metres). This can also act as a flying crane with a 4,500-pound (2,041-kilo) capacity cargo sling in which loads may be transported externally.

The H-21 and H-21A are used in the U.S. Air Force as rescue and general-purpose aircraft with ten to sixteen seats and complete winterization finish for operation in Arctic regions.

The H-21B is the U.S. Air Force assault version.

The H-21C is used by the U.S. Army for troop transport, supply and evacuation duties.

The H-21 and H-21A versions can carry twelve men on stretchers. The engine's theoretical take-off rating of 1,425 h.p. is kept down to 1,150 h.p., which is considered adequate for U.S. Air Force rescue missions.

The remaining two versions are more powerful, with 1,425 h.p. engines and a useful load of 4,500 pounds (2,041 kilos) instead of 3,500 pounds (1,588 kilos). These helicopters can transport twenty fighting men.

These helicopters all have a main entrance and a rescue door and also,

H-21C

just behind the pilot's seat, a swinging-type rescue or loading hoist which can raise a man, a stretcher or a 400-pound (181-kilo) load while hovering.

On 4 September 1953 an H-21 set up a new world record for speed over a 3-kilometre course with an average speed of 236·193 k.p.h.

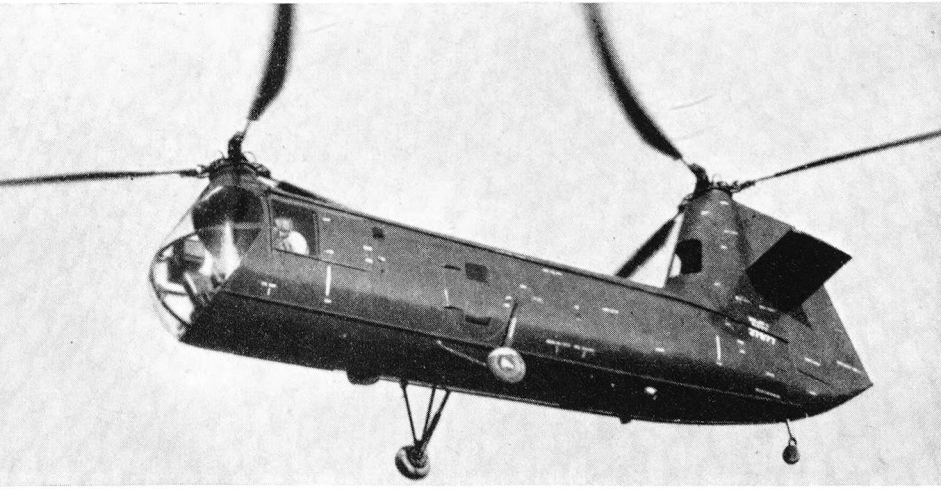
Engine: Wright R-1820-103, 1,425 h.p., derated to 1,150 h.p. in H-21 and H-21A
Rotor diameter (2)*:* 44 ft (13·41 m)
Weight empty: 8,000 lb (3,629 kg)
Weight fully loaded: 11,500 lb (5,216 kg)
Cruising speed: 100 m.p.h. (161 k.p.h.)
Inclined climb: 1,600 ft/min (488 m/min)
Absolute ceiling: 17,000 ft (5,182 m)
Range: 500 miles (805 km)
Number of seats: varies

1947 PD-14 (XHJP-1)

The project designated as PD-14 led to the prototype XHJP-1, a compact all-metal helicopter of tandem configuration with three-bladed rotors.

The first production model, the Piasecki HUP, differed from the prototype by possessing additional fins.

Engine: Continental, 525 h.p.
Rotor diameter (2)*:* 35 ft (10·67 m)
Weight: 3,800 lb (1,724 kg)
Weight fully loaded: 5,350 lb (2,427 kg)
Cruising speed: 110 m.p.h. (177 k.p.h.)



PD-14 (XHJP-1)

Inclined climb: 1,600 ft/min (488 m/min)
Range: 400 miles (644 km)
Number of seats: 6

1948 PD-18 (HUP-1) RETRIEVER

The U.S. Navy required a compact ship-based helicopter for rescue and utility purposes. The need was met by the HUP-1, which is the production model of the XHJP-1 prototype. It has fins and stabilizers not present in the original, and with blades folded it can be raised or lowered on a cruiser lift. The HUP-1 met the requirements for which it was designed and also served for personnel and cargo transport. It flew for the first time in 1950 but is at present out of production.

Engine: Continental R-975-34, 525 h.p.
Length: 32 ft (9·75 m)
Height: 13 ft 2 in (4·01 m)
Rotor diameter (2)*:* 35 ft (10·67 m)
Weight empty: 3,965 lb (1,798 kg)
Weight fully loaded: 5,736 lb (2,602 kg)
Cruising speed: 80 m.p.h. (129 k.p.h.)

PD-18 (HUP-1)

Inclined climb: 1,200 ft/min (366 m/min)
Absolute ceiling: 12,000 ft (3,658 m)
Range: 355 miles (571 km)
Number of seats: 6

1948 HUP-2 (H-25A ARMY MULE, H-25B RETRIEVER)

The HUP-2, which was a development of the HUP-1, lacked the tail surfaces found in the latter, the elimination of which was made possible through the use of a modified Sperry automatic pilot. This helicopter was used primarily for search work, rescue missions and general-purpose transport.

The H-25A version, familiarly known as the Army Mule, was used for evacuation from the front line and could carry three men on stretchers. For this purpose it had a large rescue hatch measuring 48 inches by 26 inches (122 by 66 centimetres) situated at the forepart of the cabin and adjacent to the pilot's seat. There was also a hydraulic hoist, by means of which personnel, stretchers or loads of up to 400 pounds (181 kilos) could be raised through the hatch into the cabin of the hovering helicopter. In all, 247 HUP-1s and 2s were delivered to the U.S. Navy and 19 to the French Navy, while the U.S. Army took delivery of 87 H-25As.

HUP-2:
Engine: Continental R-975-46, 550 h.p.
Length: 32 ft (9·75 m)
Height: 13 ft 2 in (4·01 m)

HUP-2

Rotor diameter (2): 35 ft (10·67 m)
Weight empty: 4,132 lb (1,874 kg)
Weight fully loaded: 5,750 lb (2,608 kg)
overload gross: 6,100 lb (2,767 kg)
Cruising speed: 80 m.p.h. (129 k.p.h.)
max: 100 m.p.h. (161 k.p.h.)
Inclined climb: 1,000 ft/min (305 m/min)
Absolute ceiling: 10,000 ft (3,048 m)
Range: 400 miles (641 km)
Number of seats: 6

H-25:
Engine: Continental R-975-46, 550 h.p.
Length: (fuselage) 32 ft (9·75 m)
Height: (fuselage) 12 ft (3·66 m)
Weight empty: 4,132 lb (1,874 kg)
Weight fully loaded: 5,750 lb (2,608 kg)
overload gross: 6,100 lb (2,767 kg)
Cruising speed: 80 m.p.h. (129 k.p.h.)
max: 100 m.p.h. (161 k.p.h.)
Inclined climb: 1,000 ft/min (305 m/min)
Absolute ceiling: 10,000 ft (3,048 m)
Number of seats: 6

1954 HUP-4 (H-25C RETRIEVER)

This more powerful version of the HUP-2 was fitted with an engine of greater output which made it superior to its predecessor in payload, speed and range.

Engine: Wright R-1300-3, 700 h.p.
Rotor diameter (2): 35 ft (10·67 m)

1953 PV-15 (YH-16 TRANSPORTER)

The PV-15 design led to the YH-16, which, like all the preceding helicopters, is of all-metal stressed-skin monocoque construction. It hardly matches the popular idea of a helicopter as small; this one compares in size to a Skymaster, and, unlike the various other Piasecki designs, has two power-plants.

To perform its duties of rescue and general-purpose transport, the YH-16 has a ramp in the forward end which can be swung forward to speed-up loading. The maximum load is 3 jeeps, 32 stretchers or 40 passengers. Outside the forward cabin door, there is a cable hoist which can be worked by the pilot.

Engines (2): Pratt and Whitney R-2180-11, 1,650 h.p., giving 3,300 h.p. in all

Length: (overall) 134 ft (40·84 m)
fuselage: 78 ft (23·77 m)
Height: 25 ft (7·62 m)
Rotor diameter: 82 ft (24·99 m)
Weight empty: over 30,000 lb (over 13,608 kg)
Number of seats: 42

PV-15

1954 YH-16A TURBOTRANSPORTER

This prototype, claimed to be the first twin-turbine-powered helicopter in the world, and known as the Turbotransporter, was powered by two shaft-drive turbines, the exhaust from one of which came out of the front fuselage, the other out of the tail.

Before its loss in December 1956 during a flight in the course of development work, the YH-16A had attained a maximum speed of 167 m.p.h. (269 k.p.h.), and a climbing speed of nearly 33 feet (10 metres) per second had been recorded.

Engines (2)*:* Allison YT38-A3 shaft turbines, 3,000 s.h.p.
Rotor diameter: 82 ft (24·99 m)
Cruising speed: 120 m.p.h. (193 k.p.h.)
Number of seats: 42 (crew of 3)

1955 YH-16B

This helicopter, also known as the Turbotransporter, is of the same general type as the former, but is powered with turbines developing 3,700 s.h.p. as against its predecessor's 3,000 s.h.p. The two engines installed were planned to enable the YH-16B to carry sixty-nine men.

PIASECKI AIRCRAFT CORPORATION

The Piasecki Aircraft Corporation of Philadelphia, Pennsylvania, was set up in 1955 when Frank Piasecki, former Board Chairman, lost control of the Piasecki Helicopter Corporation. The new group has since developed several completely enclosed vehicles with rotors such as the Seajeep and the Airjeep, and also a compound-type helicopter.

1961 16H PATHFINDER

First tested as a three-bladed helicopter, the 16H became a sort of compound aircraft through the addition of wings. These provide lift in forward flight while propulsion comes from a propeller in the ring tail. The propeller-vane arrangement in the ring tail also furnishes anti-torque and directional control. For storage, the outer wing panels fold under the rotor and the rotor blades fold aft, attaching to the top of the ring tail.

When limited space is available for a short take-off run, the 16H's wing lift enables it considerably to increase either its payload or its fuel load.

During test flights the aircraft attained a speed of 170 m.p.h. (274 k.p.h.)

Engine: UAC (Pratt and Whitney) PT6B-9, 550 s.h.p.
Length: 25 ft (7·62 m)
Height: 10 ft 7 in (3·23 m)
Rotor diameter: 41 ft (12·5 m)
Weight empty: 4,000 lb (1,814 kg)

16H PATHFINDER

Weight fully loaded: 5,700 lb (2,585 kg)
Cruising speed: 160 m.p.h. (257 k.p.h.)
Inclined climb: 1,000 ft/min (305 m/min)
Ceiling: (in ground effect) 11,500 ft (3,505 m)
Number of seats: 5

1964 16H-1A PATHFINDER II

Under a contract with the U.S. Army and support from the U.S. Navy, Piasecki has undertaken the design of an enlarged version of the 16H Pathfinder in order to study its behaviour at speeds of the order of 230 m.p.h. (370 k.p.h.)

In the new aircraft the former United Aircraft of Canada PT6 engine is replaced by the far more powerful General Electric T58-GE-8 engine of 1,250 h.p.

During tests carried out with a new air-inlet duct to improve performance, the Pathfinder II in 1966 achieved a speed of 225 m.p.h. (362 k.p.h.)

Pathfinder III is the designation for the 16H-3 fitted with twin engines: two T58-GE-10 turbines.

PITCAIRN

Shortly after World War I, Harold F. Pitcairn set about launching Eastern Airways, which specialized in the transport of airmail. This company, which Pitcairn later sold, was to become Eastern Air Lines.

Before parting company with Eastern Airways, Pitcairn became interested in the autogyros to be found in the United Kingdom. He went to England, contacted the Cierva Autogiro Company there and also took back with him to the United States an autogyro with which he gave demonstrations. He used to say: 'If we can manage a vertical take-off with a "gyro", we will have a machine that will do almost anything a helicopter will do and we won't have the headaches of a helicopter.'

Pitcairn Aircraft Inc., which had produced various single-engined aircraft to carry mail such as the PA-7 and PA-8, became the Pitcairn Autogiro Company and parent of Autogiro of America, which Pitcairn founded to exploit the La Cierva patent rights in the United States. As a result a whole series of autogyros was constructed.

The Pitcairn Autogiro Company eventually became the G and A Aircraft Division of Firestone (*q.v.*).

1930 PCA-1

This autogyro had a four-bladed rotor and wings with a span of 33 feet (10·06 metres). Flexible cables supported the blades when at rest or

turning slowly. A deflected slipstream was used to start the rotor at take-off.

One PCA-1 actually flew.

Engine: Wright J5, 200 h.p.
Width: (span) 33 ft (10·06 m)
Rotor diameter: 43 ft (13·11 m)
Weight fully loaded: 2,750 lb (1,247 kg)
Cruising speed: (max.) 105 m.p.h. (169 k.p.h.)
Number of seats: 3

1931 PCA-2 (XOP-1)

The four-bladed rotor had both drag and flapping hinges and each blade was fitted with a hydraulic damper. The actual blade consisted of a single longitudinal component made of chrome molybdenum steel with wooden struts, and the profile was given by a plywood covering.

There was a low wing with a surface area of just over 86 square feet (8 square metres).

This autogyro was the first to be commercially licensed in the United States and it flew over all the forty-eight states.

A series of twenty-four autogyros was built, and it was in one of these that J. C. Ray landed and took off from the White House in 1931 when H. F. Pitcairn received from President Hoover the Collier Trophy, which is awarded annually for the year's outstanding contributions to aeronautics in the United States. Early in 1932 a PCA-2 flew directly from Cuba to Yucatan over the Gulf of Mexico.

The U.S. Navy designation was XOP-1.

Engine: Wright J6-9, 300 h.p.
Rotor diameter: 45 ft (13·72 m)

PCA-2

Weight empty: 2,094 lb (950 kg)
Weight fully loaded: 3,000 lb (1,361 kg)
Cruising speed: min: 24 m.p.h. (39 k.p.h.)
max: 87 m.p.h. (140 k.p.h.)
Absolute ceiling: 16,400 ft (4,999 m)
Number of seats: 3

1931 PCA-3

This autogyro resembled the PCA-2 apart from the engine, which was a 300 h.p. Pratt and Whitney Wasp.

1931 PAA-1

The rotor of this autogyro was mounted on a free-rotating hub. Its four blades were braced with cables. The rotor axis could be inclined fore and aft so as to give the autogyro greater stability.
Engine: Kinner B-5, 125 h.p.
Rotor diameter: 37 ft (11·28 m)
Weight empty: 1,148 lb (521 kg)
Weight fully loaded: 1,648 lb (748 kg)
Number of seats: 2

1931 PA-18

This was a sports model, somewhat resembling the PAA-1 but with increased power and disc area. The seats in tandem were fitted with dual controls. The four blades of the rotor were mounted on a free-wheeling hub. The span of the low wing was 21 feet 3 inches (6·48 metres). Twenty-one of these aircraft were built.
Engine: Kinner R-5, 160 h.p.
Length: 19 ft 4 in (5·89 m)
Height: 11 ft 4 in (3·45 m)
Rotor diameter: 40 ft (12·19 m)
Weight empty: 1,354 lb (614 kg)
Weight fully loaded: 1,910 lb (866 kg)
Cruising speed: min: 26 m.p.h. (42 k.p.h.)
max: 100 m.p.h. (161 k.p.h.)
Absolute ceiling: 10,500 ft (3,200 m)
Number of seats: 2

1932 PA-19

An outstanding improvement in this autogyro over previous Pitcairn designs was the controllable tilt of its four-bladed rotor. The head could tilt round an axis perpendicular to the axis of the aircraft, the movement being controlled by an endless screw worked with a handle from the pilot's seat.

The landing gear had no axle-tree.

This autogyro, with its welded steel structure and four-seater cabin, was the largest yet built in America.

Engine: Wright, 420 h.p.
Rotor diameter: 50 ft 6 in (15·39 m)
Weight empty: 2,675 lb (1,213 kg)
Weight fully loaded: 4,032 lb (1,829 kg)
Cruising speed: 100 m.p.h. (161 k.p.h.)
min: 35 m.p.h. (56 k.p.h.)
max: 120 m.p.h. (193 k.p.h.)
Number of seats: 4

1932 PA-20

This autogyro had two seats in tandem open to the air, and its general appearance resembled that of the PAA-1.

1932 PA-21

This four-bladed autogyro resembled the PCA-2 but had a more powerful 420 h.p. Wright R-975 E-2 engine.

Engine: Wright R-975 E-2, 420 h.p.
Width: (span) 30 ft (9·14 m)
Rotor diameter: 45 ft (13·72 m)
Cruising speed: min: 28 m.p.h. (45 k.p.h.)
max: 125 m.p.h. (201 k.p.h.)
Number of seats: 3

1933 PA-22

This autogyro, of smaller size than the preceding, had a three-bladed rotor capable of a jump take-off.

Engine: Pobjoy Niagara, 90 h.p.
Rotor diameter: 32 ft (9·75 m)
Weight empty: 600 lb (272 kg)
Weight fully loaded: 1,140 lb (517 kg)
Cruising speed: min: 22 m.p.h. (35 k.p.h.)
max: 100 m.p.h. (161 k.p.h.)
Number of seats: 2

1932 PA-24

The PA-24 was a PAA-1 equipped with a more powerful 160 h.p. Kinner R-5 engine.

1935 PA-33 (YG-2)

This autogyro was a two-seater in tandem with no stub wings and powered by a radial engine.

In 1935 it was sent to Langley for investigation and test flights by the National Advisory Committee for Aeronautics (NACA), which gave it the Army designation YG-2 (G standing for gyroplane). YG-1 was another autogyro which had been sent to NACA at about the same time by Kellett.

Engine: Wright R-975-EQ, 420 h.p.
Rotor diameter: 46 ft 2 in (14·07 m)
Weight empty: 2,300 lb (1,043 kg)
Weight fully loaded: 3,300 lb (1,497 kg)
Cruising speed: 115 m.p.h. (185 k.p.h.)
Number of seats: 2

1936 PA-34 (XOP-2)

Apart from certain details relating to the undercarriage, this autogyro is similar to the PA-33. XOP-2 was the official designation for the United States Navy version.

1937 PA-35

This autogyro was an American version of the Westland CL-20 (*q.v.*). The rotor had three blades. One only of these rotorcraft was built.

Engine: Pobjoy, 90 h.p.
Rotor diameter: 34 ft 3½ in (10·45 m)
Weight empty: 805 lb (365 kg)
Weight fully loaded: 1,450 lb (658 kg)
Number of seats: 2

1938 PA-36

This model had an all-metal stressed skin and a cabin, as well as a ball-jointed direct-control rotor. Its engine was placed amidships.

Engine: Warner, 165 h.p.
Rotor diameter: 43 ft (13·11 m)
Weight fully loaded: 2,050 lb (930 kg)
Cruising speed: (max.) 100 m.p.h. (161 k.p.h.)
Number of seats: 2

1939 PA-39

Seven of these two-seaters in tandem were built in 1941 for the British Air Commission.

In May 1942 a PA-39 made a direct take-off and landing using a stern platform on the British ship *Empire Mersey*. As early as 1935, a British autogyro had similarly taken off from, and landed on, the Italian cruiser *Fiume*.

PLATT LEPAGE

In 1938 Havilland H. Platt, a mechanical engineer, entered into partnership with W. Laurence LePage, whose experience in the rotary-wing field was already well known: he had been an engineer first with the Pitcairn Autogiro Company, and then with the Kellett Aircraft Corporation.

On his side, Platt was credited with various projects, among them a 'Cyclogyro' going back to 1930. This aircraft was to have lateral rotors acting like the paddle-wheels of a steamship, with eccentrics to provide the requisite blade-pitch variations.

After abandoning this Cyclogyro, Platt conceived what he named a 'Vertogiro', a sort of helicopter in which torque was to be compensated by vanes situated fore and aft on the fuselage and arranged so that the downwash of air from the rotor should act upon them. These anti-torque vanes were to be provided with hinges to ensure directional control.

This particular project was followed by the joint production of a helicopter for which Platt and LePage joined forces. The configuration chosen was that used by Professor Focke for his record-breaking F-61 helicopter.

At the end of World War II, LePage had the idea of using rotors, one at each tip of the wings of conventional aircraft. These rotors would enable the aircraft to take off vertically and then, thanks to cyclic-pitch control, to continue in horizontal flight. During acceleration the rotors would tilt forward, and, tilting completed, act as airscrews.

1941 XR-1

As the result of tenders called for by the United States Government for a rotary-wing aircraft, the Platt LePage Aircraft Company was adjudged the best, and consequently on 19 July 1940 was given the second contract by the U.S. Army for the construction of a helicopter, the first having been given to De Bothezat nineteen years earlier.

The Platt LePage prototype bore resemblances to Professor Focke's F-61, in which LePage's interest had been aroused during a visit he made to Germany shortly before the outbreak of World War II, and, in fact, Platt and LePage had already done some work on it under the designation PL-3.

As the XR-1 (X standing for experimental, R for rotary wing, 1 for the first version), it had a fuselage resembling that of a conventional aircraft, and the tail was completely traditional. The engine, on the other hand, was situated towards the middle of the aircraft, and drove two rotors at the tip of streamlined pylons. The two seats were set in tandem forward. The landing gear had two main wheels and one tail wheel.

The first take-off tests were made in May 1941, and those carried out later by the Air Technical Service Command at Wright Field proved quite satisfactory. The original XR-1 was damaged in July 1943.

Engine: Pratt and Whitney R-985, 450 h.p.
Rotor diameter: 30 ft 6 in (9·3 m)
Weight fully loaded: 4,800 lb (2,177 kg)
Number of seats: 2

1943 XR-1A

This designation was given to the second prototype of the Platt LePage helicopter.

The difference between the two was that the later version had far more extensive transparent panelling. The pilot's seat was behind the observer who, because of his position in the nose, had excellent visibility.

The first successful flights took place in December 1943.

Technical details as for XR-1.

REPUBLIC AVIATION

Following an agreement with the French company Sud Aviation, the Republic Aviation Corporation assembled a small number of French 'Alouette' helicopters. Under the designation of 'Lark', they unsuccessfully took part in the U.S. Marines Assault Support Helicopter programme.

Republic tried two versions of the 'Lark', one equipped with a 525 s.h.p. Continental 217-5A engine and the other with an AiResearch Model 331 shaft-turbine.

ROTERON

In 1945 William Thomas, President of the Roteron Corporation, began work on a midget helicopter of an original design. By placing the engine between the two co-axial rotors, he had more space available in the fuselage, and considerable saving in construction costs also resulted because power was directly transmitted to the rotors. But by 1948 production had ceased.

1946 XM-1

The outstanding feature of this single-seater helicopter was the position of its 5-cylinder engine between the two contra-rotating co-axial rotors. The latter each had two sets of blades, a longer set below a shorter set which, however, produced an anti-torque effect. Both sets of blades were made of solid laminated maplewood. The pitch and speed of either rotor could be controlled and in case of engine failure they could turn by auto-rotation.

The fuselage consisted of a steel tubing frame covered with an alumi-

nium skin. The rudder, supported at the end of two tubes, could pivot from the vertical to the semi-horizontal position. The tricycle undercarriage had three fully swivelling wheels.

Engine: Noble, 25 h.p.
Width: (body) 2 ft 4 in (0·71 m)
Rotor diameter: lower blade: 7 ft 8 in (2·34 m)
upper blade: 15 ft (4·57 m)
Weight empty: 400 lb (181 kg)
Number of seats: 1

ROTOR-CRAFT

In 1945 the Rotor-Craft Corporation began developmental work on a helicopter with tandem-rotor configuration, designed by its President, Gilbert W. Magill, and embodying various novel features, especially the use of a rigid-rotor system. The only designer in the United States to have preceded Magill in this line was Landgraf, who employed side-by-side rotor blades fixed rigidly to the hubs.

In 1953 Rotor-Craft acquired the patents of the Landgraf Helicopter Company, including those relating to 'rigid rotors'. At the time Magill stated: 'Rigid-rotor helicopters will be less costly to produce, and the safety of rigid blades that cannot droop and endanger passengers or others approaching the machine is expected to be attractive to both armed services and commercial helicopter operators.'

The absence of reliable technical data about its own particular version of the rigid-rotor concept decided Rotor-Craft to design a test stand which would enable a quarter-scale rotor assembly to be thoroughly tested during the developmental stage.

1946 XH-II DRAGONFLY

This helicopter had two three-bladed rotors set in tandem and overlapping though separated by a distance of 12 feet 4 inches (3·76 metres); the level of the rear rotor was above that of the forward rotor.

The blades, rigidly attached to the hub, were connected in such a way that their span axis was at the rear of the driving shaft.

For forward or backward flight the swash plate was tilted fore and aft by a push-pull rod, while collective pitch change was obtained by raising or lowering another push-pull rod. The swash plate was mounted, not beneath the rotor hub, but at the base of the driving shaft.

The aircraft's centre of gravity was closer to the front than to the rear rotor, which thus resulted in heavier disc loading upon the forward than upon the rear rotor.

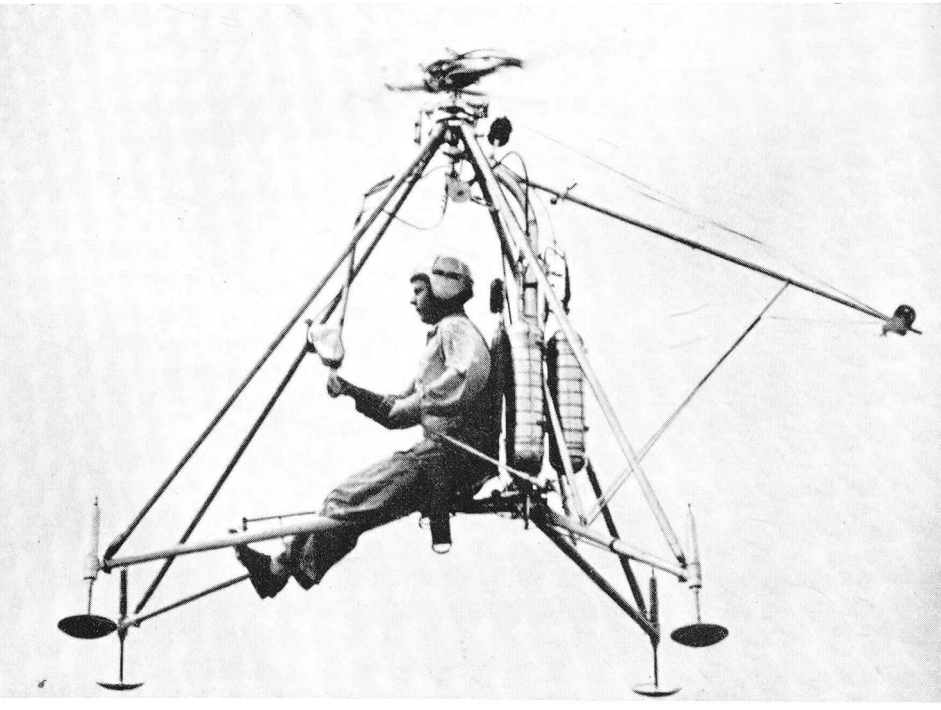
Consideration was given to developing an extrapolation of the Dragon-

fly, to be known as the Rotorbus, a helicopter capable of carrying twenty passengers.

Engine: Continental A-100, 100 h.p.
Length: (overall) 15 ft (4·57 m)
Height: 7 ft 6 in (2·29 m)
Rotor diameter (2)*:* 18 ft (5·49 m)
Weight empty: 900 lb (408 kg)
Weight fully loaded: 1,350 lb (612 kg)
Number of seats: 1–2

1951 RH-1 PINWHEEL

This rocket-engined prototype, developed for the United States Navy, was designed so that it could be used by 'strapping-on'. The rotor was driven by two liquid-fuel rockets. Nitrogen gas under pressure forced hydrogen peroxide stored in two tanks through the hub and blades. At the tip of the latter, the hydrogen peroxide came into contact with a catalyst, and the resultant thrust was sufficient to turn the blades at



RH-1 PINWHEEL

more than 500 r.p.m. No hydraulic system, starter or electricity was used in the Pinwheel.

Originally equipped with Reaction Motors XLR-32RM rocket units of the same type as used in the Kellett KH-15, the RH-1 eventually had rockets developed by Rotor-Craft itself, which are throttle-controlled, and it thus differs from previous helicopters of this type, in which the power setting could be only 'on' or 'off'. The RH-1 made its maiden flight during 1954.

Engines (2): Rotor-Craft rockets
Rotor diameter: 17 ft (5·18 m)
Cruising speed: 60 m.p.h. (97 k.p.h.)
Range: 9 minutes (endurance)
Number of seats: 1

RUSSELL

Charles Russell, President of Russell Aircraft, a small Missouri firm, has built an autogyro resembling the Bensen Gyro-Copter. There is one difference—the engine is not a McCulloch but a small aircraft engine. Plans and kits for building are to be made available to amateurs.

1963 RUSSELL (BR-1)

The Russell Gyro-Plane has a Bensen-type rotor but the engine may be either a 65 h.p. Lycoming or a 60 h.p. Franklin, driving a pusher propeller 4 feet 11 inches (1·5 metres) in diameter. The designer's determination to obtain maximum concentration of bulk led him to a structure differing slightly from the Bensen. From the base of the rectangular tube supporting the two-bladed rotor run four square-section tubes respectively carrying the three landing gear wheels and the tail and tail skid assembly. The rotor has an oscillating hub and is controlled by a conventional stick. It has a fuel tank holding 30 Imperial gallons (136 litres).

Engine: Lycoming, 65 h.p.
Length: 9 ft 2 in (2·79 m)
Height: 6 ft 6 in (1·98 m)
Rotor diameter: 26 ft (7·92 m)
Weight empty: 400 lb (181 kg)
Weight fully loaded: 700 lb (318 kg)
Cruising speed: 60 m.p.h. (97 k.p.h.)
Rate of climb: 900 ft/min (274 m/min)
Range: 100 miles (161 km)
Number of seats: 1

1963 BR-2

Identical with the BR-1, apart from a three- instead of a two-bladed rotor with the same diameter. The engine is a Franklin 2A-120 of 60 h.p.

1965 BR-3

This model uses the basic BR-1 airframe, but is fitted with a three-bladed rotor and a propeller duct having an internal diameter of 4 feet $11\frac{3}{4}$ inches (1·52 metres). Just aft of this duct is placed a rudder. The engine is a Lycoming of 65 h.p.

The BR-4 is an agricultural version, equipped with a more powerful Franklin engine.

SAALFELD

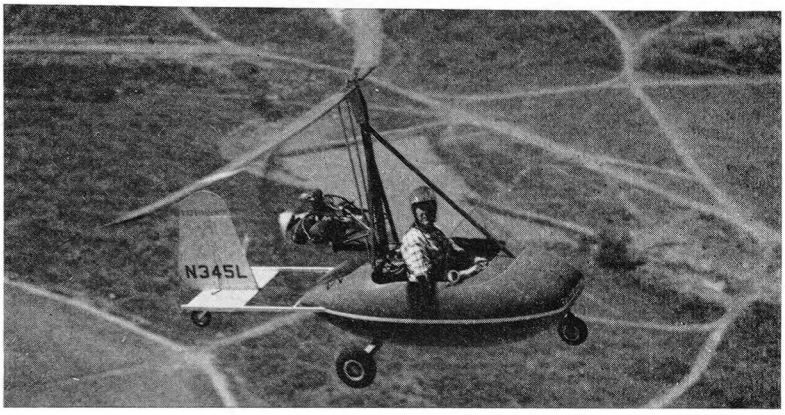
While the Saalfeld Aircraft Company's aircraft recalls the popular Bensen Gyro-Copter, it differs from it by providing quite comfortable accommodation for two passengers. It was originally available in kit or plan form, but from 1965 onwards has been sold only as a completed, certified aircraft.

1960 SKYSKOOTER

This compact lightweight autogyro has a welded steel airframe, to which is bonded a moulded fibreglass fuselage. All the basic flight instruments are mounted on a cockpit panel. The engine is behind the two-bladed rotor pylon and the landing gear is of the tricycle type, with self-equalizing brakes.

The Skyskooter prototype made its maiden flight in October 1960. Its take-off run varies from 100 to 300 feet (30·5 to 91·4 metres) and its landing roll is 20 feet (6·1 metres).

Engine: McCulloch, 4318A, 72 h.p.
Length: 10 ft (3·05 m)
Height: 6 ft 6 in (1·98 m)
Rotor diameter: 21 ft (6·4 m)
Weight empty: 275 lb (125 kg)
Weight fully loaded: 650 lb (295 kg)
Cruising speed: 65 m.p.h. (105 k.p.h.)
min: 25 m.p.h. (40 k.p.h.)
max: 85 m.p.h. (137 k.p.h.)
Rate of climb: 1,000 ft/min (305 m/min)
Range: 250 miles (402 km)
Number of seats: 2



SKYSKOOTER

SCHEUTZOW

The Scheutzow Helicopter Corporation was set up at Berea, Ohio, to develop an experimental design by Webb Scheutzow. At the end of the war he had worked on rotorcraft with Kellett and then a few years later as designer on the UH-12 with Hiller. Scheutzow's helicopter includes a patented design for a vee-belt-driven rotor with a hub incorporating a new suspension system.

1963 MODEL B

This is a small, lightweight, two side-by-side seat helicopter with the engine mounted vertically and driving the main and tail rotors through a centrifugal clutch and a multiple vee-belt drive system.

The main rotor has two blades. These are rubber-mounted in a system known as Flexhub. The normal need for lubrication is thus eliminated. The rotor has proved satisfactory in the test flights carried out. Production models will be fitted with a 165 h.p. engine.

Engine: Continental, 85 h.p.
Length: 18 ft 6 in (5·64 m)
Height: 7 ft (2·13 m)
Rotor diameter: 23 ft (7·01 m)
Weight empty: 736 lb (334 kg)
Weight fully loaded: 1,200 lb (544 kg)
Cruising speed: 75 m.p.h. (121 k.p.h.)
Range: 2½ hours (endurance)
Number of seats: 2

SCHMIDT

George Schmidt worked with Focke-Achgelis in his native Germany until 1939. He then left his homeland for the United States, where he worked for fourteen years in various American aircraft factories. Finally, as a private venture and unaided, he set about achieving his plans to adapt the pulse-jet engine to helicopter rotors.

Schmidt has, incidentally, designed a new pulse-jet engine, far less noisy than the conventional variety. Noise reduction is obtained by placing a water-spray nozzle in the ejection chamber. The very high temperature there converts the water into a steam mass which escapes from the tail of the ejection chamber through a series of ultra-high-frequency tubes.

1953 PARACOPTER

This was the development of a strap-on helicopter which was destroyed through mishandling during its first tests.

The two-bladed rotor was powered by two 105-pound (47·6-kilo) thrust engines, mounted on ball bearings at the tip of the blades and having a certain freedom of up-and-down movement. The engines themselves, 32 inches (81 centimetres) in length and with a maximum diameter of 5 inches (12·7 centimetres), weighed only 17½ pounds (7·94 kilos) and were fitted aft with stabilizing fins.

They ran on a special fuel based on kerosene and stored under pressure in a tank situated behind the pilot's seat. Once the fuel reached the rotor head, it was distributed centrifugally, and a bottle of compressed air was used to start the pulse-jet engine.

The helicopter was made of welded steel tubing with a folding tricycle landing gear. Space was provided under the pilot's seat for a stretcher to be used in casualty evacuation.

The Paracopter made its first flight in 1953.

Engines (2)*:* Schmidt 105-lb (47·6-kg) thrust pulse-jets
Height: 8 ft 7 in (2·62 m)
Rotor diameter: 17 ft 5 in (5·31 m)
Weight empty: 265 lb (120 kg)
Weight fully loaded: 775 lb (352 kg)
Cruising speed: 110 m.p.h. (177 k.p.h.)
Absolute ceiling: 12,300 ft (3,749 m)
Range: 70 minutes (endurance)
Number of seats: 1

SCHRAMM

Buford Schramm of Los Angeles, a former student in aeronautical

engineering, together with four partners, formed the Schramm Corporation to build his design for a car-sized helicopter.

1965 SCHRAMM JAVELIN

This is a small single-seater with a two-bladed rotor, which uses swash plate cyclic-pitch control, and which has an empty weight of about 500 pounds (227 kg).

Engine: Continental O-200, 100 h.p.
Length: 25 ft $0\frac{1}{4}$ in (7·65 m)
Height: 6 ft $1\frac{1}{2}$ in (1·89 m)
Rotor diameter: 21 ft $4\frac{3}{4}$ in (6·53 m)
Weight empty: 500 lb (227 kg)
Weight fully loaded: 882 lb (400 kg)
Range: 143 miles (230 km)
Number of seats: 1

SEIBEL

Seibel first worked with Bell in Arthur Young's team when it was putting the finishing touches to the Model 30. In 1946 he left Bell to take up a position as aerodynamicist with the Boeing Airplane Company for the development of a liaison aircraft.

Seibel however, did not abandon rotorcraft. In conjunction with George Lubben and Dick Ledwin, he built the S-3, a small helicopter with a rotor of outstanding simplicity. Lateral and longitudinal control were effected by changing the centre of gravity.

Early in 1948 Seibel and his partners formed the Seibel Helicopter Company Inc. and set about building larger aircraft, the S-4A and later the S-4B.

The Seibel Helicopter Company eventually became a division within the Cessna organization.

1947 S-3

Each of the two blades was attached to the rotor hub by means of a metal sheet bent so as to form an angle. Movements of this 'blade attaching angle', which could (as it were) be twisted, controlled pitch changes. There was thus no need for bearings, hinges, dampers, etc.

In addition, as stated above, lateral and longitudinal control were effected by changing the centre of gravity. By using a stick attached at its lower end to a swivel fitting to the fuselage structure, the pilot could displace his cabin, which was mounted on links, forwards, backwards or to either side.

This helicopter made its maiden flight on 20 September 1947.

Engine: Franklin, 65 h.p.

Rotor diameter: 25 ft (7·62 m)
Weight empty: 540 lb (245 kg)
Weight fully loaded: 800 lb (363 kg)
Cruising speed: 70 m.p.h. (113 k.p.h.)
Inclined climb: 900 ft/min (274 m/min)
Absolute ceiling: 12,000 ft (3,658 m)
Number of seats: 1

1948 S-4A (YH-24 SKYHAWK)

The rotor was fitted with the same 'blade attaching angle' system as patented for the S-3. In this tandem-seating helicopter, the passenger, payload and fuel supply are carried at the centre of gravity, just beneath the main rotor gearbox.

YH-24 is the designation for the military version of the S-4A.
Engine: Lycoming O-290-D, 125 h.p.
Rotor diameter: 29 ft (8·84 m)
Weight empty: 960 lb (435 kg)
Weight fully loaded: 1,500 lb (680 kg)
Cruising speed: 60 m.p.h. (97 k.p.h.)
Inclined climb: 700 ft/min (213 m/min)
Absolute ceiling: 10,400 ft (3,170 m)
Range: 115 miles (185 km)
Number of seats: 2

1949 S-4B

This version of the preceding helicopter differed from it not only in having greater power but also by virtue of a shortened fuselage which could accommodate two pilots side-by-side. In addition, the S-4A's wheeled landing gear was replaced by one fitted with skids.

Engine: Franklin 6A4-165-B3, 165 h.p.
Rotor diameter: 29 ft (8·84 m)
Weight empty: 1,100 lb (499 kg)
Weight fully loaded: 1,650 lb (748 kg)
Cruising speed: 70 m.p.h. (113 k.p.h.)
Inclined climb: 1,350 ft/min (411 m/min)
Absolute ceiling: 14,000 ft (4,267 m)
hovering: 5,700 ft (1,737 m)
Range: 110 miles (177 km)
Number of seats: 2–3

SIKORSKY

When Igor Ivanovitch Sikorsky was nineteen he bought a 25 h.p. Anzani

engine in Paris, returned to his homeland, Russia, and there in 1909 built his first helicopter. The latter consisted of a wooden frame with two two-bladed contra-rotating rotors, the upper 15 feet (4·57 metres), the lower 16 feet 6 inches (5·03 metres) in diameter. During its trials the aircraft shook as if palsied, but remained stubbornly fixed to the ground. In the following year Sikorsky built another helicopter which, in its maker's own words, 'with its slender propellers in motion . . ., resembled a huge butterfly'. Like a butterfly, this craft could lift its own weight off the ground, but refused to lift even a single passenger.

Sikorsky then gave up rotary wings in favour of traditional aircraft, and the sixth which he built won him the highest award at the 1912 Moscow Aviation Show. Now backed by a huge combine known as the Russian Baltic Railway Car Company, he set about building the largest aircraft ever attempted at that period, a four-engine design. After the outbreak of World War I, he built heavy bombers for the Imperial Russian Army.

On the outbreak of the 1917 revolution, Sikorsky left Russia and in 1919 settled in the U.S.A. Some years later he was back in the aeronautical industry and in 1923 his new company, the Sikorsky Aero Engineering Corporation, produced the S-29, a metal transport plane; this was later followed by the S-38, an amphibious aircraft used by Pan American Airways. Sikorsky had meanwhile become an American citizen.

In 1929 Sikorsky's firm was taken over by the United Aircraft Corporation, whose products included Pratt and Whitney engines, Hamilton Standard Propellers and Chance Vought aircraft. Sikorsky was then responsible for the S-40, a four-engined clipper aircraft.

Finally, thirty years after his first incursions into the rotary-wing field, Sikorsky produced a rotorcraft of a new design, the VS-300, which in 1941 remained airborne for 1 hour 32 minutes 26 seconds. This helicopter had a single lifting rotor and a smaller tail rotor turning more rapidly and at right-angles to the other so as to cancel out torque. Cancelling out torque was the major problem Sikorsky had to overcome in developing his helicopter ideas.

As far back as 1929 he had taken out a patent relating to these matters. Air mixed with suitable gases pressurized by a blower was to be expanded by appropriate heating during its passage through rotor blades fitted with jet orifices on the lifting side. Lack of funds at the time prevented further research along those lines.

The successful flight of the VS-300 led to contracts for the construction of a larger rotorcraft, the R-4, which was used by the U.S. Army Air Force, Coast Guard and Navy as well as by the British Royal Air Force.

In all his later designs Sikorsky has tended to follow the principle of a single main rotor. As he personally expresses his views: 'One woman in the kitchen is fine: two women in the kitchen get in each other's way!'

By the end of 1964 Sikorsky had delivered about 4,500 helicopters;

furthermore his rotorcraft were or still are manufactured under licence in France, Great Britain and Japan.

Amongst the projects developed by Sikorsky during and after 1966, two deserve special mention: the ABC (Advancing Blade Concept) design is a rotor system using—for once—two co-axial contra-rotating rigid rotors; and the jointly projected Sikorsky-North American CARA (Combat Aircrew Recovery Aircraft), which would take off vertically and then fold its rotor blades and fly horizontally at very high speeds.

The following list gives the original main series designations of rotorcraft in use with the American Armed Forces: the several variants of each are described in separate entries.

1940	VS-300				
1942	R-4 (VS-316)			HNS-1	
1943	R-6			HOS-1	
1943	R-5			HO_2S	
1946	S-51	H-5		HO_2S	HO_3S
1947	S-52	H-18		HO_5S	
1949	S-55	H-19	HRS	HO_4S	
1953	S-56	H-37	HR_2S		
1954	S-58	H-34	HUS-1	HSS-1	
1954	S-59	H-39			
1956	S-60				
1958	S-61	SH-3	CH-3	HSS-2	RH-3
1958	S-62	HH-52			
1962	S-64	CH-54			
1964	S-65	CH-53			

1940 VS-300

Early in 1939, when engineering manager of the Vought Sikorsky Division of the United Aircraft Corporation, Sikorsky had on his drawing-board the plans of an experimental rotary-wing framework, which by September of the same year had become an aircraft ready for its take-off trials.

Nicknamed 'Igor's Nightmare' because of the number of changes it underwent during the development stage, it finally succeeded in making its first free flight in May 1940. It could climb vertically, hover, fly sideways and even backwards, but it could not fly forward. Questioned about this, Sikorsky had a stock reply: 'That is one of the minor engineering problems we have not yet solved.' Later, when reminded about this, Sikorsky disarmingly confessed: 'The helicopter appeared so reluctant to fly forward that we even considered turning the pilot's seat around and letting it fly backward!'

Eventually, on 15 April 1941, the VS-300 (V for Vought, S for Sikorsky) not only flew forward but even beat the American endurance record with

a flight of 1 hour 5 minutes 15 seconds. On 6 May 1941 its 90 h.p. engine beat the previous world endurance record held by Professor Focke's 160 h.p. aircraft with a new time of 1 hour 32 minutes 26 seconds.

The record-breaker had gone through three main developmental stages. It first looked rather like a Christmas tree with three airscrews on outriggers placed aft to provide some degree of control and stability. During 1941 one of the airscrews was removed, but another was kept at the tail tip on top of a metal pylon to provide fore-and-aft control, while lateral control came from the vertical airscrew. In December 1941, as a final improvement, the horizontal airscrew was removed, and the surviving vertical tail rotor was given a feathering action in the blades. This was Sikorsky's eighteenth version on his experimental framework. This configuration had come to stay: the main rotor providing lift and the small tail rotor counteracting torque and simultaneously acting as rudder are common to all the long series of Sikorsky helicopters.

Among the various experiments Sikorsky made with his framework was the first amphibious American helicopter to fly. This was on 17 April 1941, when, using a version with pneumatic bags fastened to the undercarriage, Sikorsky successfully took off from a river and later landed on a meadow without help from wheels.

Sikorsky also tested a two-bladed, in place of a three-bladed, rotor, and found that the simpler rotor mechanism produced performances comparable with those of the more complex one. However, Sikorsky did not pursue this line because he considered the vibrations caused by the two-bladed rotor to be excessive. The technical details below apply to the final version.

VS-300

Engine: Franklin, 100 h.p.
Length: 28 ft (8·53 m)
Height: 10 ft (3·05 m)
Rotor diameter: 30 ft (9·14 m)
Weight fully loaded: 1,150 lb (522 kg)
Range: 75 miles (121 km)
Number of seats: 1

1942 VS-316 (R-4 OR HNS-1)

Successful trials with the VS-300 led to the VS-316 with twice the size and power. The 7-cylinder air-cooled radial engine was placed behind the cabin and the engine was fitted with a large fan which drew in the air needed for cooling through louvres situated on the forward face of the rotor pylon casing.

Cyclic pitch was obtained by means of a movable swash plate placed beneath the joints connecting the blades through to their shaft. In addition, a further control enabled the pitch of all the blades to be instantly raised or lowered.

The airscrew at the tail, with blades whose pitch could be both varied

R-4

and reversed, cancelled out torque effects and was also used for making turns. Some 15 h.p. was required to power it. The same general principles are applied in all Sikorsky's later productions.

When fitted with floats, this helicopter could be carried aboard a merchant ship on a platform 40 feet square (12·19 by 12·19 metres), from which it took off for spotter duties in convoy protection work, but it was not powerful enough to carry depth charges for offensive use. In May 1943 it made its first landing at sea on board the tanker *Bunker Hill.*

R-4 was the Air Force designation; HNS-1 the Navy designation. In all, 130 of these helicopters were built during the war. The first consignment of them to reach the United Kingdom arrived late in 1944; they were used for radar calibration and for air-sea rescue work.

Engine: Warner R-550-1, 185 h.p.
Length: 48 ft 1 in (14·66 m)
Height: 12 ft 1 in (3·68 m)
Rotor diameter: 38 ft (11·58 m)
Weight fully loaded: 2,540 lb (1,152 kg)
Cruising speed: 65 m.p.h. (105 k.p.h.)
Absolute ceiling: 8,000 ft (2,438 m)
Range: 200 miles (322 km)
Number of seats: 2

1943 R-6 (HOS-1)

Originally intended merely as a more advanced version of the R-4, this

R-6

version underwent numerous changes while in construction and emerged much more streamlined with a moulded plastic cabin.

It was equipped with a 6-cylinder engine horizontally opposed in-line with the crankshaft in the vertical plane.

Total production of these helicopters, known in the U.S. Navy as the HOS-1, reached 225.

Engine: Franklin O-405-9, 235 h.p.
Length: 47 ft 11 in (14·6 m)
Rotor diameter: 38 ft (11·58 m)
Weight fully loaded: 2,600 lb (1,179 kg)
Cruising speed: 70 m.p.h. (113 k.p.h.)
Inclined climb: 800 ft/min (244 m/min)
Ceiling: 10,000 ft (3,048 m)
Number of seats: 2

1943 R-5 (HO2S-1)

Preliminary ground tests started in the summer of 1943 on this helicopter designed for reconnaissance and carrying depth charges to be used in anti-submarine work. This involved a useful load of 1,500 pounds (680 kilos) and consequently a more powerful engine and a larger rotor.

In the R-5, the R-4 side-by-side seating arrangements were altered to seats behind each other.

This helicopter successfully performed the unusual test of climbing with eighteen people aboard. Some were inside the cabin, others outside it on planks fastened to the fuselage. The total payload thus carried amounted to 2,540 pounds (1,152 kilos).

On 14 November 1946 this aircraft, which the U.S. Navy knew as the HO2S-1, broke the world's speed record over 1,000 kilometres with an average of 107·251 k.p.h.

Engine: Pratt and Whitney R-985-AN-5, 450 h.p.
Length: 44 ft 11½ in (13·71 m)
Height: 13 ft (3·96 m)
Rotor diameter: 48 ft (14·63 m)
Weight empty: 3,650 lb (1,656 kg)
Weight fully loaded: 4,900 lb (2,223 kg)
Cruising speed: 85 m.p.h. (137 k.p.h.)
Inclined climb: 1,200 ft/min (366 m/min)
Absolute ceiling: 14,000 ft (4,267 m)
Range: 260 miles (418 km)
Number of seats: 2

1946 S-51 (HO3S OR H-5)

Developed from the HO2S-1 (also known as the R-5), the S-51 was the first Sikorsky helicopter to have been licensed by the Civil Aviation

Authority (C.A.A.) for commercial operation, and was well known in the services as the H-5 by the United States Air Force and as the HO3S-1 and 2 by the United States Navy.

This four-seater helicopter had a three-bladed rotor with flapping and drag hinges; the blades of all-metal construction could be folded to facilitate storage. Initially, the pitch of the main rotor was under direct manual control, but this was later replaced by hydraulic servo-controls with power from a hydraulic pump driven by the tail transmission shaft.

At the end of 1951 Sikorsky's Bridgeport (Connecticut) factories stopped producing the S-51, of which 285 were built. This S-51, Sikorsky's first commercial helicopter, saw extensive service in Korea. It was also produced under licence by the British firm of Westland.

Engine: Pratt and Whitney R-985-AN-7, 450 h.p.
Length: 41 ft $1\frac{3}{4}$ in (12·54 m)
Height: 12 ft 11 in (3·94 m)
Rotor diameter: 48 ft (14·63 m)
Weight empty: 3,975 lb (1,803 kg)
Weight fully loaded: 5,500 lb (2,495 kg)
Cruising speed: 85 m.p.h. (137 k.p.h.)
Inclined climb: 1,000 ft/min (305 m/min)
Absolute ceiling: 13,500 ft (4,115 m)
Range: 260 miles (418 km)
Number of seats: 4

S-51

1948 XHJS-1 (S-53)

This model, of which three prototypes in all were built for the U.S. Navy could carry three to five persons. A floor hatch enabled an inside

hoist to be operated for hauling up people or freight. There was complete equipment for night flying.

Engine: Continental R-975-34, 500 h.p.
Rotor diameter: 49 ft (14·94 m)
Weight fully loaded: 5,300 lb (2,404 kg)
Cruising speed: 90 m.p.h. (145 k.p.h.)
Inclined climb: 1,000 ft/min (305 m/min)
Absolute ceiling: 19,000 ft (5,791 m)
Range: 330 miles (531 km)
Number of seats: 3–5

1947 S-52 (H-18 OR HO5S-1)

The design of this helicopter embodied the lessons learnt from both the R-4 and the R-6. It had an improved rotor head in which the action of the blade flapping hinges coincided with that of the drag hinges, thereby ensuring far better control.

The S-52-2, a felicitous compromise between the small two-seater version and a medium-sized helicopter, was an S-52-1 with an enlarged cabin, which could seat more passengers. It was also fitted with a more powerful motor, which had been moved aft and stood in an inclined position. The payload capacity was 81 cubic feet (2·3 cubic metres). Stability was also increased by adding ventral fins to the tail boom.

In 1949 the original version of the S-52 set up several world records (see under World Records).

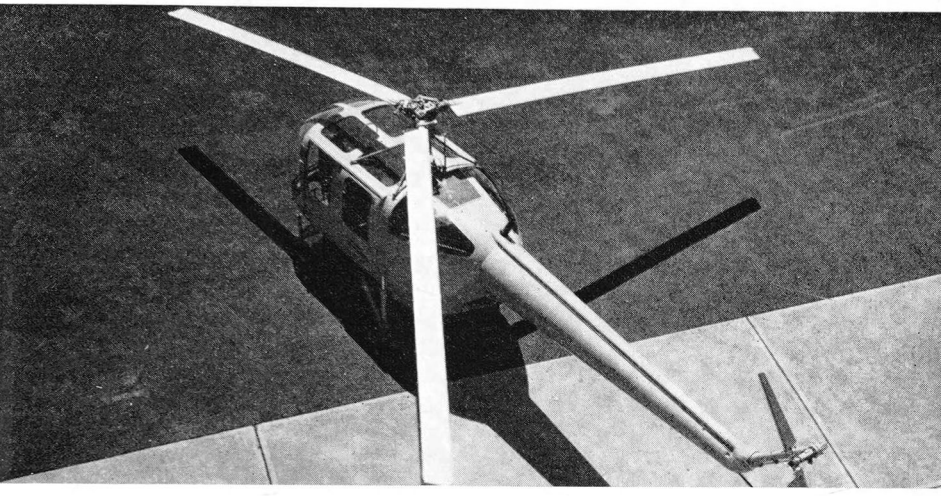
The S-52 was widely used during the operations in Korea, where it was known to the U.S. Air Force as H-18 and to the U.S. Navy as HO5S-1. The successor to the S-52, powered by a turbine, is the S-59.

S-52-1:

Engine: Franklin, 178 h.p.
Length: (overall) 27 ft 5 in (8·36 m)
Rotor diameter: 33 ft (10·06 m)
Weight fully loaded: 2,100 lb (950 kg)
Cruising speed: 80 m.p.h. (129 k.p.h.)
Inclined climb: 10,000 ft/min (305 m/min)
Absolute ceiling: 11,500 ft (3,505 m)
Range: 250 miles (402 km)
Number of seats: 2

S-52-2:

Engine: Franklin 6V6-245-B16, 245 h.p.
Length: (overall) 27 ft 5 in (8·36 m)
Rotor diameter: 33 ft (10·06 m)
Weight fully loaded: 2,700 lb (1,225 kg)
Cruising speed: 96 m.p.h. (154 k.p.h.)



S-52

Absolute ceiling: 22,200 ft (6,767 m)
Range: 290 miles (467 km)
Number of seats: 4

1949 S-54

Sikorsky conceived this model to study the twin-rotor configuration which he ultimately abandoned, since he considered that at cruising speed the tail rotor did not absorb any more power than that lost owing to rotor interference with twin rotors.

1949 S-55 (H-19, HO4S, HRS, ETC.)

The main feature of this helicopter is the oblique position of the engine placed in the nose of the fuselage, where a large two-section door makes maintenance or replacement very simple. The adjacent pilot's seat has excellent visibility and is located in front of and above the passenger cabin. The latter can seat ten passengers or carry a freight load. The military version includes lifting gear so that casualties can be taken aboard the helicopter in stationary flight. The four-wheeled landing gear can be fitted with rubber floats. When using auxiliary fuel tanks, the S-55 has covered ferrying distances of up to 1,000 miles (1,609 kilometres).

This is an extremely versatile helicopter for both civil and military use. In the former version it has been adopted by various airlines and has flown under all climatic conditions. During operations in Korea, on ambulance duty, it evacuated more than 2,000 wounded men in less than one year, and on rescue work, it picked up over 500 soldiers or sailors. The S-55 licence was granted in France to SNCASE (*q.v.*) and it was mass-produced

in the United Kingdom as the Whirlwind by Westland Aircraft Ltd (*q.v.*), again under licence.

The following list gives the various designations and specialized uses in the U.S. armed forces of the S-55, of which 1,281 were built.

Air Force:	YH-19; H-19A; UH-19B (formerly H-19B); and HH-19B (formerly SH-19B) UH-19B was fitted with a Wright R-1300-3
Army:	UH-19C (formerly H-19C); and UH-19D (formerly H-19D), UH-19D fitted with a Wright R-1300-3
Navy:	HO4S-1 and 2; UH-19F (formerly HO4S-3), fitted with a Wright R-1300-3
Marine Corps:	HRS-1 and 2; CH-19E (formerly HRS-3), fitted with a Wright R-1300-3
Coast Guard:	HH-19G (formerly HO4S-3G)

To obtain extra lift, the HRS-2 above employs the ROR—rocket on rotor—system. A rocket engine with fuel for six minutes provides thrust from the rapid catalytic decomposition of hydrogen peroxide equivalent to 20 per cent more power than obtained from the standard engine. An ordinary HRS-2 can carry two pilots and six fully equipped men, the ROR HRS-2 carries two pilots and ten Marines with full equipment.

Engine: Pratt and Whitney R-1340-57, 600 h.p., or Wright R-1300-3, 800 h.p.

Length: 42 ft 2 in (12·85 m)

Height: 14 ft 8 in (4·47 m)

S-55

Rotor diameter: 53 ft (16·15 m)
Weight empty: 4,795 lb (2,175 kg)
Weight fully loaded: 7,200 lb (3,266 kg)
Cruising speed: 85 m.p.h. (137 k.p.h.)
Inclined climb: 700 ft/min (213 m/min)
Absolute ceiling: 10,500 ft (3,200 m)
Range: 405 miles (652 km)
Number of seats: 12

1953 S-56 (CH-37, HR2S)

Designed to meet the requirements of an assault transport for the U.S. Marine Corps, where its designation is now CH-37C instead of the former HR2S, this helicopter has a five-bladed rotor powered by two reciprocating engines mounted on stub wings and housed in nacelles outside and above the fuselage. The engines are placed in such a way that a straight-through drive is achieved to the main central gearbox. The stub wings, which assist lift in cruising flight, also act as fuel tanks.

The nose is fitted with clamshell doors so that vehicles can be easily loaded. A traversing electric hoist with a 2,000-pound (907-kilo) capacity permits a cargo to be easily hoisted into the cabin. There is a retractable undercarriage as well as a castoring and lockable tail wheel. The helicopter also has automatic stabilization and semi-automatic blade-folding equipment. There is also a 10,000-pound (4,536-kilo) capacity automatic touchdown release cargo sling to carry external loads.

The assault version is fitted with nylon anti-flak curtains and can transport thirty-six men with all their equipment or one 105-millimetre gun or three 'Mighty Mite' U.S. Navy jeeps.

HR2S-1W is the designation of a U.S. Navy variant carrying a large early warning radar.

The U.S. Army version, the H-37 Mojave, was ultimately given the designations CH-37A and CH-37B.

This helicopter, of which 156 were built, in November 1956 set up a world speed record over a three-kilometre base at an average of 261·91 k.p.h., and also an altitude record of 2,000 metres with a payload of 6,010 kilos.

Engines (2)*:* Pratt and Whitney R-2800, each 2,100 h.p.
Length: (fuselage) 64 ft 10¾ in (19·78 m)
Width: 27 ft 4 in (8·33 m)
Height: 17 ft 9½ in (5·42 m)
Rotor diameter: 72 ft (21·95 m)
Weight empty: 20,690 lb (9,385 kg)
Weight fully loaded: 31,000 lb (14,061 kg)
Cruising speed: 115 m.p.h. (185 k.p.h.)
max: 130 m.p.h. (209 k.p.h.)

Inclined climb: 910 ft/min (277 m/min)
Service ceiling: 8,700 ft (2,652 m)
Range: 200 miles (322 km)
Number of seats: 36

1954 S-57 (PROJECT)

This was a proposal for a jet VTOL convertiplane combining the speed of a swept-back fixed-wing aircraft with the versatility of a helicopter. Taking off as a helicopter, it would use the counter-balanced rotor powered by air diverted from a turbojet. During high-speed flight the entire rotor system was to be retracted and stored into the fuselage.

The following are Sikorsky's own views on the subject: 'Only the future will indicate whether the advantages gained will compensate for the complications, cost and weight involved.'

1954 S-58 (CH-34, HUS-1)

This enlarged version of the S-55 has a much more powerful engine fitted at 34 degrees in the nose.

The rear fuselage is fitted with a large fin and a small fixed tail plane as well as a tail wheel. Furthermore, the tail pylon is hinged so that it can be folded laterally for storage purposes.

This version has one main rotor with four metal blades and an anti-torque rotor, also with four metal blades. Space is provided to carry, in addition to a crew of two, either eighteen passengers or eight casualties on stretchers. Its 'convoyage' range, i.e. range with additional fuel tanks and no payload, can be brought up to 925 miles (1,489 kilometres).

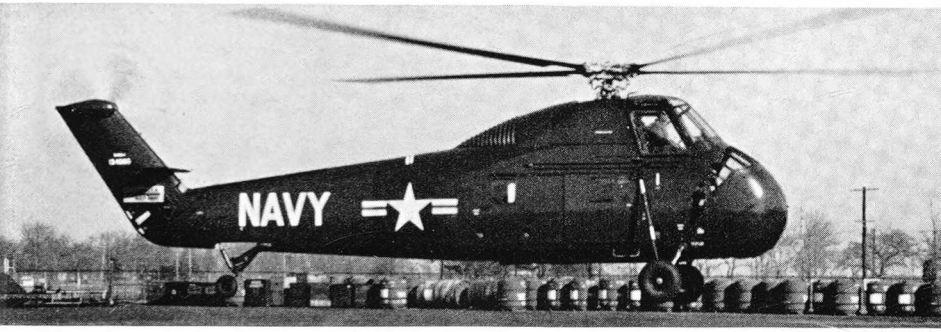
A licence to build the S-58 was granted to the French Company Sud Aviation and to the British firm of Westland, from which it developed the Wessex.

The S-58, of which the record number of 1,887 were built, in July 1956 set up several world records over closed circuits of 100, 500 and 1,000 kilometres.

Its various designations in the U.S. Armed Forces are as follows:

Army:	CH-34A (H-34A) Choctaw; CH-34C (H-34C) Choctaw with airborne search equipment; VH-34C VIP transport
Marine Corps:	UH-34D (HUS-1) Seahorse; UH-34E (HUS-1A) Seahorse with pontoons; HUS-1AN; VH-34D (HUS-1Z) VIP transport
Navy:	YSH-34G (YHSS-1); SH-34G (HSS-1) Seabat; SH-34H (HSS-1F) version re-engined with shaft-turbine; SH-34J (HSS-1N) Seabat with automatic stabilization system.
Coast Guard:	HH-34F (HUS-1G) search and rescue.

Engine: Wright R-1820, 1,525 h.p.
Length: 44 ft 2 in (13·46 m)
Width: 12 ft 9 in (3·89 m)
Height: 14 ft 4 in (4·37 m)
Rotor diameter: 56 ft (17·07 m)
Weight empty: 7,900 lb (3,583 kg)
Weight fully loaded: 13,000 lb (5,897 kg)
Cruising speed: 97 m.p.h. (156 k.p.h.)
max: 122 m.p.h. (196 k.p.h.)
Inclined climb: 1,100 ft/min (335 m/min)
Service ceiling: 9,500 ft (2,896 m)
Range: 247 miles (398 km)
Number of seats: 14–20



S-58

1954 S-59 (H-39)

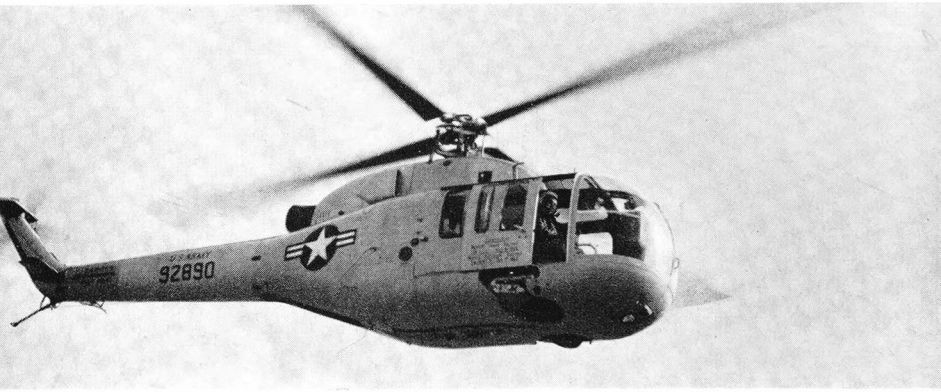
This helicopter, successor to the S-52, has a relatively small-sized rotor with a quite high rate of revolutions, driven by a gas-turbine of the Turboméca type.

Constructionally, the S-59 is an assembly of various component units. The metal cabin has an inverted tricycle undercarriage; the two front wheels retract laterally beneath the cabin floor, while the rear wheel retracts into the lower section of the fuselage.

The turbine engine, reduction and driving box form a very compact unit located above the cabin. Finally there is the rear section and the arm which holds the three-bladed tail rotor.

The S-59, of which two only were built, were used as flying test beds for turbines, and in August 1954 set up a new world record for speed over a 3-kilometre base with an average of 156·006 m.p.h. (251·067 k.p.h.). Also, in the same year, the record altitude of 24,521 feet (7,474 metres) was reached.

Engine: (gas-turbine) Turboméca Artouste II
Length: (overall) 41 ft 7 in (12·67 m)
Height: 11 ft 2 in (3·4 m)
Rotor diameter: 35 ft (10·67 m)
Weight empty: 2,050 lb (930 kg)
Weight fully loaded: 3,600 lb (1,633 kg)
Cruising speed: 135 m.p.h. (217 k.p.h.)
Inclined climb: 1,260 ft/min (384 m/min)
Absolute ceiling: 24,500 ft (7,468 m)
Range: 250 miles (402 km)
Number of seats: 4



S-59 (H-39)

1959 S-60

This rotorcraft, tests of which started in March 1959, is a huge crane helicopter prototype of a design evolved from the Sikorsky S-56. It uses the latter's dynamic components: main and tail rotors, blades, transmission parts and driveshafts, as well as the same piston-engine, the Pratt and Whitney R-2800.

The main cabin is eliminated in favour of a bridge-like tail boom, which provides space below the fuselage for the loading or unloading of huge bulky objects, not only when the helicopter hovers but also while it is on the ground. A new cockpit design gives the pilot a glass-enclosed cabin with unobstructed vision in all directions. The pilot's seat can swivel to the rear so that he can observe any loading or unloading operations; in this backward-facing position he operates a separate set of controls looking almost directly down the hoist to the cargo.

The structure's weight has been reduced to the minimum to increase

payload capacity. At military establishments the S-60 has carried out demonstrations with a twenty-seat 'people pod'.

This prototype was used in the development of the Skycrane S-64 fitted with turbines.

Engines (2)*:* Pratt and Whitney R-2800-54, 2,100 h.p. each
Height: 17 ft (5·18 m)
Rotor diameter: 72 ft (21·95 m)
Weight empty: 19,613 lb (8,896 kg)
Weight fully loaded: 31,200 lb (14,152 kg)
Cruising speed: (max.) 130 m.p.h. (209 k.p.h.)
Ceiling: (in ground effect) 6,800 ft (2,073 m)
Range: 265 miles (426 km)
Number of seats: 2

S-60

1958 S-61 (SH-3, CH-3, RH-3, ETC.)

The first Sikorsky 61, the S-61B, made its maiden flight in March 1959 with the designation HSS-2, later changed to SH-3A Sea King. This boat-hull helicopter was designed to seek, detect and destroy submarines in all weather by day or night.

It has a five-bladed main rotor system, two turbine-engines, a fuselage stressed for operation on water, retractable landing gear and an automatic blade-folding system. It is equipped with automatic stabilization equipment, the latest automatic doppler radar navigation devices and protection against icing on the engines and windshield. In 1961 it set up world speed records over 3- and 100-kilometre straight courses at 198·84 m.p.h. (320 k.p.h.) and 182·7 m.p.h. (294·12 k.p.h.) respectively. It was similarly an

SH-3A which, taking off from the U.S. Navy Aircraft-carrier *Hornet* at San Diego, California on 6 March 1965, landed 15 hours 52 minutes later on the deck of the carrier *Franklin D. Roosevelt* near Jacksonville, Florida, after having covered 2,105·63 miles (3,388·7 kilometres).

The SH-3A was the forerunner to several S-61 production models.

During 1965 production started of the SH-3A converted to the SH-3D; first deliveries were made during 1966. The SH-3D has the same appearance as its predecessor but more powerful engines—T58-10s, growth versions of the T58-8s used on the SH-3A. The flying time is thereby extended from 4 hours to 4 hours 30 minutes. The SH-3D is in service with the U.S. and Spanish Navies and is built under licence by Westland in the United Kingdom, Agusta in Italy, and Shin Mitsubishi Heavy Industries in Japan.

RH-3A is the U.S. Navy designation for a version of SH-3A used for airborne mine counter-measures duties. The minesweeper version differs externally from the SH-3A by incorporating a starboard cabin door.

The S-61 was used early in 1962 to meet the U.S. Air Force requirement for a transport helicopter to support Texas Towers in the Atlantic. This requirement was met by a helicopter in every respect identical with the SH-3A except for the special equipment it carries. It is a stripped-down SH-3A with seats added for 27 men. This utility transport's U.S. Air Force designation is CH-3B; the civil version is the S-61A.

S-61D is the designation of an SH-3 project with doors and loading ramps and also a monorail loading system, an option on the licence for which was granted early in 1961 to Weser Flugzeugbau GmbH, Germany.

The S-61F is a thrust-assisted version of the SH-3A. Developed under a joint U.S. Army and Navy research and development contract to study higher operating speeds at high operating weights, it achieved in 1965 a speed of 242 m.p.h. (389 k.p.h.) in level flight at a gross weight of approximately 17,000 pounds (7,710 kilos). It is powered, in addition to the two T58-8s, by two Pratt and Whitney J60 turbojet engines, each providing 2,750 pounds (1,247 kilos) of thrust, on either side of the fuselage.

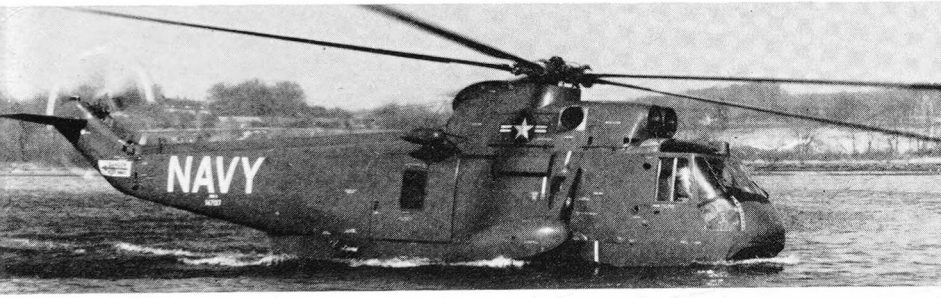
S-61L and S-61N are respectively land and amphibian commercial airliner versions of the SH-3A. The fuselage, specifically lengthened for airline operation, measures 59 feet 7 inches (18·16 metres), the cabin length is 31 feet 11 inches (9·73 metres). Each of the two engines is a CT58-110-1 of 1,250 h.p. The S-61N differs from the S-61L in having a sealed hull with sponsons and a higher tail pylon. The S-61L has flown on Los Angeles Airways scheduled passenger flights since early 1962. Late in that year, the first S-61N was delivered to Mitsubishi of Japan. Since then it has joined the helicopter fleets of Pakistan International Airways, B.E.A., Ansett ANA, Greenlandair, and other airlines. It is also used in support of offshore oil-drilling operations.

The S-61R rear-loading helicopter for troop and cargo transportation

duties was selected in November 1962 by the U.S. Air Force, where it is designated the CH-3C. It made its maiden flight in June 1963 and became fully operational in December of that year. It is fitted with a rear ramp, a nose wheel and airfoil-shaped sponsons housing retractable landing gear. The fuselage aft, the tail cone and tail pylon were all modified to complement the rear ramp. Its designation with two uprated engines is CH-3E.

The HH-3E is a modified version of the CH-3C, popularly known as the 'Jolly Green Giant' and used by the Aerospace Rescue and Recovery Service. It has external droppable fuel tanks, armour plating and sophisticated communications and electronic equipment. On 1 June 1967 two of these rotorcraft flew non-stop from New York to Paris with nine refuellings in flight. The HH-3F is a version developed in 1967 and is in service, supplementing the U.S. Coastguard's HH-52A.

The 61V or VH-3A is the executive version of the SH-3A and is used by the U.S. Army and Marines for the transport of VIPs.



S-61

S-61N

S-61A
Engines (2): General Electric T58-GE-8B, 1,250 s.h.p. each
Length: (fuselage) 54 ft 9 in (16·69 m)
Width: 13 ft (3·96 m)
Height: 16 ft 10 in (5·13 m)
Rotor diameter: 62 ft (18·9 m)
Weight empty: 9,911 lb (4,496 kg)
Weight fully loaded: 19,100 lb (8,664 kg)
Cruising speed: 145 m.p.h. (233 k.p.h.)
max: 159 m.p.h. (256 k.p.h.)
Inclined climb: 1,500 ft/min (457 m/min)
Service ceiling: 12,800 ft (3,901 m)
Range: 541 miles (871 km)
Number of seats: 28

S-61B
Weight empty: 11,419 lb (5,180 kg)
Weight fully loaded: 18,044 lb (8,185 kg)
Cruising speed: 150 m.p.h. (241 k.p.h.)
max: 162 m.p.h. (261 k.p.h.)
Inclined climb: 1,690 ft/min (515 m/min)
Service ceiling: 14,700 ft (4,481 m)
Range: 625 miles (1,006 km)

S-61L and S-61N
Engines (2): General Electric CT58-110-1, 1,250 s.h.p. each
Length: (L) 58 ft 11 in (17·96 m)
(N) 59 ft 4 in (18·08 m)
Height: (L) 16 ft 10 in (5·13 m)
(N) 18 ft 10 in (5·74 m)
Weight empty: 12,047 lb (5,464 kg)
Weight fully loaded: 19,000 lb (8,618 kg)
Cruising speed: 140 m.p.h. (225 k.p.h.)
max: 146 m.p.h. (235 k.p.h.)
Inclined climb: 1,300 ft/min (396 m/min)
Service ceiling: 11,500 ft (3,505 m)
Range: 276 miles (444 km)
Number of seats: 30

S-61R
Engines (2): General Electric CT58-110-1, 1,250 s.h.p. each
Length: 57 ft 3 in (17·45 m)
Height: 18 ft 1 in (5·51 m)
Weight empty: 11,500 lb (5,216 kg)

Weight fully loaded: 19,500 lb (8,845 kg)
Cruising speed: 145/165 m.p.h. (233/266 k.p.h.)
Inclined climb: 1,100 ft/min (335 m/min)
Service ceiling: 11,700 ft (3,566 m)
Range: 500 miles (805 km)
Number of seats: 30

1958 S-62 (HH-52A)

The S-62A first flew at Stratford, Connecticut, in the Spring of 1958. It is the first amphibious helicopter with a flying-boat-type hull, which enables it to operate from land, water, ice, snow or swampland. The 'V' bottom of the fuselage is designed to cushion the impact of a water-landing by throwing the spray outwards and downwards, and is entirely watertight. For land operation, wheels are mounted under the floats, which are located forward and well away from the fuselage.

The S-62 is powered by a turbine on top of the fuselage, its weight being about one-third that of the S-55's piston-engine. The S-62 shares many of the S-55's components: the main and tail rotor heads and blades; main, intermediate and tail gearboxes; shafting and tail rotor pylons; and majo. features of the flight control and hydraulic systems.

This craft, which by 1962 had been sold to around twenty airlines and other customers, can carry 3,000 pounds (1,361 kilos) of internal or slung freight. There is an S-62B version, identical save for its S-58-type rotor, which has its blades slightly cropped.

A search and rescue version, the HH-52A (formerly HU2S-1G), has been in service with the U.S. Coast Guard since 1963. The commercial model of the HH-52A is known as the S-62C.

Engine: General Electric T58-GE-8B, 1,250 s.h.p.
Length: 44 ft 7 in (13·59 m)
Width: 15 ft (4·57 m)
Height: 14 ft 2 in (4·32 m)
Rotor diameter: 53 ft (16·15 m)
Weight empty: 4,903 lb (2,226 kg)

S-62

Weight fully loaded: 8,100 lb (3,674 kg)
Cruising speed: 98 m.p.h. (158 k.p.h.)
max: 110 m.p.h. (177 k.p.h.)
Inclined climb: 960 ft/min (293 m/min)
Service ceiling: 10,200 ft (3,109 m)
Range: 494 miles (795 km)
Number of seats: 14

1962 S-64 (CH-54A SKYCRANE)

Experiments with the flying crane S-60 led to the concept of the S-64 with all the advantages of gas-turbine engines. A BMW 6012 engine acts as an auxiliary and starter for the S-64's engines. The S-64, which made its maiden flight on 9 May 1962, is a universal transport vehicle for both military and industrial purposes. It can indeed serve as a personnel and cargo transport, a flying crane, and also an aerial towing vehicle.

This helicopter is designed to carry its cargo externally. The slender boom, towering 9 feet 4 inches (2·84 metres) above the ground over its entire length, has a flat underside for snug fit-loading of vans or pallets. The topside of the boom provides a level platform for the engines, the six-bladed main rotor, the four-bladed tail rotor 15 feet (4·57 metres) in diameter and the transmission system. Loads of up to 19 feet (5·79 metres) in width fit comfortably between the wheels of the main landing gear.

The S-64 (known in the U.S. Army as the CH-54A) has one unusual feature: behind the normal pilot's position there is a separate seat and set of flight controls from which the rotorcraft can be manœuvred with the pilot facing backwards towards the cargo. By 1965 six CH-54As were in operation with the U.S. Army and two with the West German Ministry of Defence. S-64E is the commercial designation.

On 24 April 1965 this helicopter set up three world altitude records: 29,341 feet (8,943 metres) with a payload of 2,204·6 pounds (1,000 kilos); 28,743 feet (8,761 metres) with 4,409·2 pounds (2,000 kilos) and 21,371 feet (6,514 metres) with 11,023·1 pounds (5,000 kilos).

The CH-54B Skycrane, which had reached the design stage in 1967, is a growth version of the CH-54A, planned to be able to lift about 18 tons (about 18,300 kilos). It will be powered by three T64-GE-16 turbine engines rated at 3,435 s.h.p. each, and the rotor will have seven blades and a diameter of 79 feet (24·1 metres).

Engines (2)*:* Pratt and Whitney JFTD-12A, 4,050 s.h.p. each
Length: (overall) 87 ft 6 in (26·67 m)
Width: 21 ft 10 in (6·65 m)
Height: 18 ft 7 in (5·66 m)
Rotor diameter: 72 ft (21·95 m)
Weight empty: 17,240 lb (7,820 kg)
Weight fully loaded: 38,000 lb (17,237 kg)

Cruising speed: 110 m.p.h. (177 k.p.h.)
max: 124 m.p.h. (200 k.p.h.)
Inclined climb: 1,400 ft/min (427 m/min)
Service ceiling: 10,500 ft (3,200 m)
Range: 172 miles (277 km)
Number of seats: 2–3

S-64

1964 S-65 (CH-53A, HH-53B)

The CH-53A, a heavy-assault transport helicopter designed for the U.S. Marine Corps, first flew on 14 October 1964. It is powered by two turbines housed in streamlined nacelles; the main transmission and the six-bladed rotor are similar to those developed for the S-64 Skycrane. By contrast, the rotor head has an automatic blade-folding system, so too has the tail. An auxiliary power-plant, a Solar T62T-12 turbine located ahead of the transmission, acts as a hydraulic system to start the engines.

The helicopter's entire bottom is watertight and the sponsons on each side of the fuselage enable it to float for a certain time. Fuel cells are located in the forepart of each sponson, which also contains the main gear assemblies. The tricycle undercarriage is fitted with twin wheels on each leg.

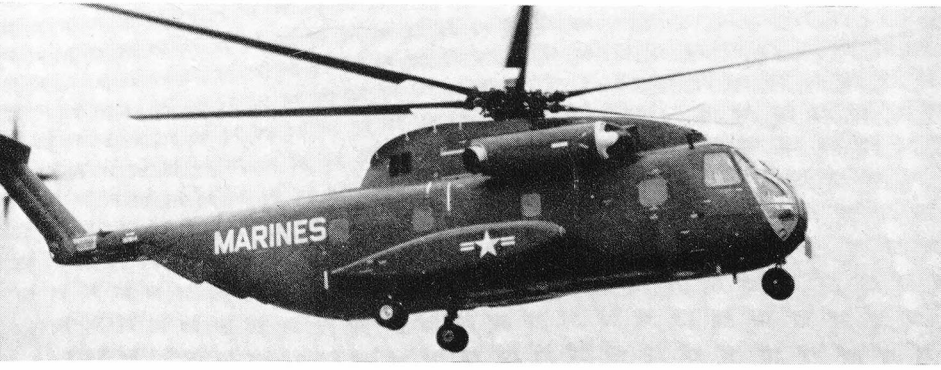
Flown by a three-man crew, the CH-53A can carry thirty-eight troops fully equipped for combat; as a flying ambulance it can take twenty-four patients and four attendants. The cabin measuring 30 feet (9·14 metres) in length, 6½ feet (1·98 metres) in height and 7½ feet (2·29 metres) in width has a full-sized rear opening door for loading and unloading on the ground. The helicopter can transport two jeeps or two Hawk M-3

missiles, plus cable reels and control console, or a 105-millimetre Howitzer complete with its carriage.

S-65 is the designation of a civil version of the CH-53A under development for inter-city flights. It can carry sixty-seven passengers in a longer and wider cabin.

In 1966, Sikorsky was awarded a contract to build the HH-53B heavy-lift helicopter for use by the U.S. Air Force in its Aerospace Rescue and Recovery Service. Powered by two T64-GE-3 turboshaft engines, each of 3,080 s.h.p., it made its maiden flight during the first quarter of 1967. Its equipment is much the same as that of the HH-3E 'Jolly Green Giant' on active service with the Aerospace Rescue and Recovery Service. HH-53C is an advanced version of the HH-53B.

Engines (2)*:* General Electric T64-GE-6, 2,850 s.h.p. each
Length: 67 ft 2 in (20·47 m)
Width: 15 ft 5 in (4·7 m)
Height: 16 ft 6 in (5·03 m)
Rotor diameter: 72 ft (21·95 m)
Weight empty: 20,950 lb (9,503 kg)
Weight fully loaded: 33,484 lb (15,188 kg)
Cruising speed: 172 m.p.h. (277 k.p.h.)
max: 195 m.p.h. (314 k.p.h.)
Inclined climb: 1,820 ft/min (555 m/min)
Service ceiling: 16,700 ft (5,090 m)
Range: 282 miles (454 km)
Number of seats: 41



S-65

1965 S-66

S-66, the designation of a project under development for the U.S. Army's Advanced Aerial Fire Support System (AAFSS), takes the form of a compound helicopter. It has fixed wings and can be fitted with a device

which Sikorsky calls a Rotorprop, which acts both as a helicopter tail rotor and a pusher propeller by turning 90 degrees aft in high-speed flight, while directional control is supplied by a conventional aircraft rudder. During 1965 the Rotorprop was tested on a modified S-61. The switch-over from the anti-torque to the pusher propeller function takes place when a speed of 80 m.p.h. (129 k.p.h.) is reached.

SUN

In 1950 the Sun Helicopter Company built a somewhat unusual prototype, the most striking feature of which was a single-bladed rotor.

1950 SUN MODEL 1

This helicopter with two seats in tandem has an unusual single-bladed rotor, with a piece of steel acting as counterweight on the opposite side and controls consisting of a hanging stick.

The engine is just behind the axle on which the rotor turns and immediately above two of the undercarriage's three wheels.

Engine: 95 h.p.
Rotor diameter: single blade measuring 13 ft (3·96 m)
Weight empty: 650 lb (295 kg)
Weight fully loaded: 1,150 lb (522 kg)
Cruising speed: 85 m.p.h. (137 k.p.h.)
Number of seats: 2

TEICHER HUNT

William E. Hunt, who had formerly been a project engineer with Sikorsky and a design engineer with the Piasecki Helicopter Corporation, designed a simplified helicopter, built in 1947 under the name of Humming Bird. Simplicity was the keynote of the aircraft: its direct-tilting hub eliminated mechanical cyclic pitch changing. In flight the rotor shaft inclined forwards in the horizontal plane, so the fuselage did not assume the inclined-forward position common to most helicopters. Since the rotor blades were rigidly interconnected, only a single flapping hinge was required. The only pitch control, that for collective pitch, was hydraulically operated. A single fly-weight-type governor, located directly above the engine, was used for automatic pitch changing.

Tests on this helicopter were performed by the Frontline Helicopter Corporation, before the latter became a subsidiary of Glenview Metal Products. Glenview later took over the prototype and as the result of the above preliminary tests replaced the original Franklin by a more powerful

Lycoming engine and re-designed the engine mounting, the clutch and the power transmission system.

1947 HUMMING BIRD

Engine: Lycoming, 125 h.p.
Length: (overall) 35 ft 6 in (10·82 m)
fuselage: 24 ft 4 in (7·42 m)
Height: 8 ft 7 in (2·62 m)
Rotor diameter: 30 ft 6 in (9·3 m)
Weight empty: 1,150 lb (522 kg)
Weight fully loaded: 1,655 lb (751 kg)
Cruising speed: 90 m.p.h. (145 k.p.h.)
max: 108 m.p.h. (174 k.p.h.)
Inclined climb: 1,200 ft/min (366 m/min)
Service ceiling: 12,500 ft (3,810 m)
Number of seats: 2

TRANSCENDENTAL

The Transcendental Aircraft Corporation, a small company, put the final touches to an aircraft designed and built by Mario A. Guerierri. This prototype, known as the Model 1G, was a single-seater convertible helicopter with two contra-rotating rotors located at the end of its wings. These three-bladed rotors acted as normal helicopter rotors, but they could also be swivelled forward to become the traction airscrews of a typical aircraft, lift then being provided by the fixed wings.

Thanks to contracts signed with the U.S. Air Force in 1952 and 1953, the Transcendental Aircraft Corporation was able to solve a number of problems, and more particularly that of instability phenomena occurring when the rotors were swivelled forward.

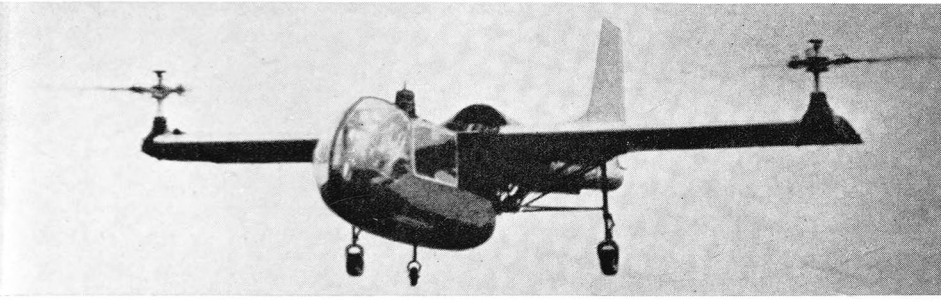
1954 MODEL 1G

Since a helicopter rotor behaves differently from a conventional airscrew, a compromise had to be worked out. The engine reduction has been replaced by a two-gear reduction box, at the exit of which a gearing system has been attached which enables the rotors to be put into autorotation. At the engine's maximum output of 3,000 r.p.m. the rotors rotate at 633 r.p.m. as airscrews, and at 240 r.p.m. as helicopter rotors.

Three concentric tubes start from the swivelling device, the first of which moves the rotor, the second controls cyclic variation, and the third, variation of collective pitch. The time needed to move from the helicopter to the aircraft position is roughly three minutes. In this changeover, the rotors swivel through an angle of 82 degrees.

Model 1G flew for the first time as a helicopter in June 1954 and as a convertible in December 1954.

Engine: Lycoming O-290-A, 160 h.p.
Length: 26 ft (7·92 m)
Width: 38 ft (11·58 m)
Height: 7 ft (2·13 m)
Rotor diameter (2)*:* 17 ft (5·18 m)
Weight empty: 1,450 lb (658 kg)
Weight fully loaded: 1,750 lb (794 kg)
Maximum speed: as helicopter: 115 m.p.h. (185 k.p.h.)
as aircraft: 160 m.p.h. (257 k.p.h.)
Absolute ceiling: as aircraft: 5,000 ft (1,524 m)
Range: 90 minutes (endurance)
Number of seats: 1



MODEL 1G

1957 MODEL 2

This is an improved successor to the Model 1G, powered by a 250 h.p. Lycoming O-435-23 engine mounted behind the cabin and driving two fully articulated rotors. A Model 3 has been projected. It will also be convertible and designed to take two gas-turbines.

UMBAUGH

Raymond E. Umbaugh started to develop a single-seater autogyro of the Bensen Gyro-Copter type, incorporating various improvements. The two-bladed rotor is fitted with a teeter stop and there is also a clutch-operated spin-up mechanism. The fuel tanks are now placed beneath the pilot's seat.

Encouraged by his first experiments, Umbaugh set about building a

two-seater version intended initially as a runabout and later as a utility helicopter. In carrying out this programme Umbaugh Aircraft Corporation encountered many difficulties over setting up a mass-production line. They first contacted Fairchild to subcontract the airframes, then Peace River Manufacturing Corporation became interested in the rotorcraft, which finally in 1964 was planned for production by Air and Space Manufacturing, Inc. of Muncie, Indiana.

1958 MODEL 18

This is a two-seater tandem autogyro with the engine driving a two-blade pusher propeller. It is equipped with a low-set boom which carries a tail plane and three vertical surfaces. This triple tail design was the last of many configurations tested.

An ejector system has been selected for engine cooling. The three-blade rotor can be pre-rotated for a jump take-off.

Engine: Lycoming O-360, 180 h.p.
Length: 19 ft 10 in (6·05 m)
Width: 9 ft 6 in (2·9 m)
Height: 9 ft 3 in (2·82 m)
Rotor diameter: 35 ft (10·67 m)
Weight empty: 1,200 lb (544 kg)
Weight fully loaded: 1,800 lb (816 kg)
Cruising speed: 100 m.p.h. (161 k.p.h.)
max: 126 m.p.h. (203 k.p.h.)
Inclined climb: 700 ft/min (213 m/min)
Service ceiling: 12,000 ft (366 km)
Range: 300 miles (483 km)
Number of seats: 2

VERTOL

Vertol Aircraft Corporation was the name taken after 1955 by the Piasecki Helicopter Corporation, after Piasecki himself had left and set up the Piasecki Aircraft Corporation (*q.v.*).

Vertol thus continues to manufacture and improve its existing rotorcraft, and is particularly concerned with the problem of adapting gas-turbines to helicopters.

During 1960 Vertol in its turn was taken over by the Boeing Airplane Company of Seattle. Even as a division of Boeing, however, Vertol continues to operate at its factories in Morton, Pennsylvania.

The main rotorcraft built by Vertol and Boeing Vertol are, by model number, as follows:

42 42A	CH-21A
43 44A, B, C	CH-21C
63	HUP-4
71	H-21D
107	CH-46
	UH-46
114	CH-47

1956 MODEL 44

This is an improved version of the H-21 Work Horse (see under Piasecki [Helicopter Corporation]) which has proved its worth in long service with the U.S. Air Force and Army, the Royal Canadian Air Force, and the French and German armed forces.

Some of the major differences between the 44 and the H-21C are: all-metal rotor blades, reduced drag, and a roll-rate damper stability device resulting in improved flying qualities. There are three basic versions of this model.

Model 44A is a utility passenger or cargo carrier. Seating arrangements allow for 19 passengers in civilian, and 20 in military, transportation. Bulky items can be carried externally on a 2½-ton cargo sling. Deliveries have been made to the U.S. Air Force, Royal Canadian Air Force, and the Royal Swedish Navy and Air Force.

Model 44B, for commercial passenger services, carries 15 persons and provides a 50-cubic foot (1·4-cubic metre) compartment for mail, cargo and express consignments. This helicopter has been operated by New York Airways, Sabena and Spartan Air Service and also used in the construction and petroleum industry.

Model 44C is a *de luxe* executive transport.

Engine: Wright Cyclone 977-CpHD1, 1,425 h.p.
Length: (fuselage) 52 ft 6 in (16 m)
Width: 14 ft 4 in (4·37 m)
Height: 15 ft 5 in (4·7 m)
Rotor diameter: (each) 44 ft (13·41 m)
Weight empty: 8,990 lb (4,078 kg)
Weight fully loaded: 14,350 lb (6,510 kg)
Cruising speed: 100 m.p.h. (161 k.p.h.)
Inclined climb: 1,050 ft/min (320 m/min)
Service ceiling: 9,600 ft (2,926 m)
Range: 322 miles (518 km)
Number of seats: 21

1956 H-21D (MODEL 71)

Piasecki's project PD-22 led to the YH-21, itself followed by the production model H-21A, or Model 42. This eventually led to the H-21B and H-21C, with the new designations CH-21B and CH-21C, equivalent to Vertol 43.

H-21D is the designation given to two standard H-21s modified for the U.S. Army with twin General Electric T58 gas-turbines. These engines take up less space and weigh less than the H-21's single piston engine. The modified helicopters successfully completed a series of test programmes which confirmed the advantages expected from a twin-turbine installation.

1956 MODEL 105

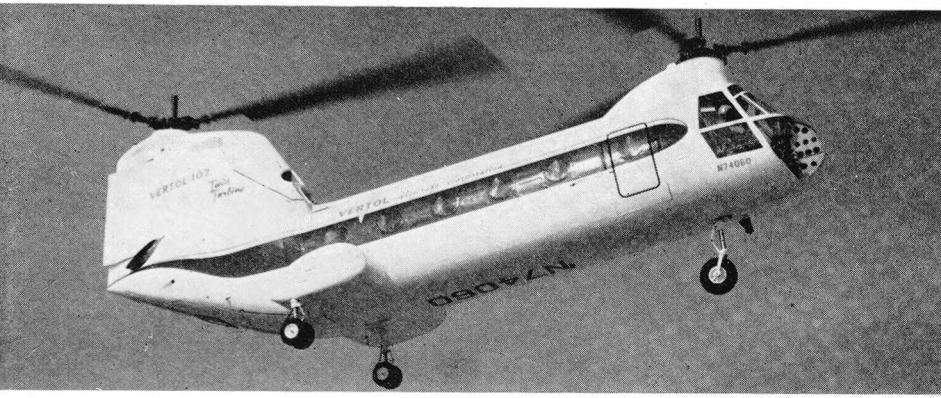
This is the designation of a Vertol-owned H-21 with a Lycoming T53 twin-turbine installation. The substitution of this power-plant for the Wright R-1820-103 reciprocating engine results in a 50 per cent increase in cruising speed and a 40 per cent increase in payload, as well as other advantages such as multi-engine reliability. The maiden flight took place in 1957.

Engines (2)*:* Lycoming T53-C2
Length: (fuselage) 52 ft 6 in (16 m)
Width: 14 ft 4in (4·37 m)
Rotor diameter: (each) 44 ft (13·41 m)
Weight empty: 8,923 lb (4,047 kg)
Weight fully loaded: 14,700 lb (6,668 kg)
Cruising speed: 138 m.p.h. (222 k.p.h.)
max: 149 m.p.h. (239 k.p.h.)
Inclined climb: 1,720 ft/min (524 m/min)
Ceiling: 12,700 ft (3,871 m)
Number of seats: 22

1957 MODEL 107 (CH-46) SEA KNIGHT

The rapid development of the 107, of a size lying between the HUP-1 and the H-21, is partly due to Vertol's extensive multi-turbine experience. The YH-16A flew successfully on power from two Allison T38 shaft-turbines; the Vertol 105 was powered by two Lycoming T53 turbines and the H-21D by two General Electric T58 turbines. Another factor was the experience gained in the field of tandem-rotor layout: by the time the Model 107 was under development, more than 1,000 tandem rotors had already been manufactured.

The prototype Vertol Model 107 with two Lycoming T53 turbines, developed as a private venture, made its maiden flight in April 1958. Shortly afterwards there was an evaluation order from the U.S. Army for a military version. This resulted in the U.S. Army YHC-1A which made



MODEL 107

its first flight in August 1959. This rotorcraft was also evaluated by several foreign military agencies.

The two rotors are three-bladed, fully articulated in tandem and partially overlapping. They are also interchangeable. The engines are placed side by side at the base of the aft pylon. This necessitates a shaft running through the entire length of the cabin up to the front rotor. The cabin has been designed for compactness to minimize the space taken up by the craft on board ship. The cabin has a constant cross-section from the cockpit to the rear pylon. The all-metal fuselage is of semi-monocoque construction and the lower section is sealed against water at the factory to ensure good flotation capability. The landing gear and fuel-cell stubs are also sealed, ensuring good stability when the helicopter is afloat. There is both a side entry and a rear loading-ramp which can remain open during flight to carry elongated cargo. Model 107 can operate under any weather conditions because of its Stability Augmentation System (SAS) device.

In the course of development, the prototype 107 and the YHC-1A (redesignated the CH-46C by the U.S. Department of Defense) led to the 107-II with a transmission system capable of absorbing a greater power output. The Boeing Vertol 107-II, certified by the Federal Aviation Agency early in 1962 as a transport helicopter, started its commercial airline career with New York Airways in 1962 as a replacement for the Vertol 44. The commercial version is also used in Japan, where Kawasaki has a licensing agreement.

A special version of the 107-II won a U.S. Navy design competition for an assault transport helicopter to operate with the U.S. Marine Corps. Production orders followed for this model, designated CH-46A Sea

Knight. Deliveries started in June 1964 of the Navy version UH-46A, of which the primary duty is vertical replenishment. These rotorcraft are fitted with two T58-GE-8 turbines with a maximum power of 1,250 s.h.p. each.

During 1966 deliveries started of a version with more powerful turbines, the T58-GE-10, giving a maximum power of 1,400 s.h.p. This version is known as CH-46D in the U.S. Marine Corps and UH-46D in the U.S. Navy. It achieves better performance through increased power and an improved rotor blade.

The CH-113 Labrador is the version of the 107-II used since 1963 by the Royal Canadian Air Force for rescue duties. Two T58-GE-8 engines provide 1,250 s.h.p. of maximum power. The CH-113A Voyageur is the version used since 1964 by the Canadian Army as a troop and cargo transport.

HKP-4 is the designation of the Swedish version on duty in the Swedish Navy on anti-submarine hunt-and-kill duties and in the Swedish Air Force for search and rescue work. The Swedish versions are fitted with two Bristol-Siddeley Gnome H.1200 turbines each of 1,250 s.h.p.

Engines (2)*:* T58-GE-8B, 1,250 s.h.p. each
Length: (fuselage) 44 ft 10 in (13·67 m)
Width: (overall) 14 ft 6¼ (4·43 m)
Height: (overall) 16 ft 8½ in (5·09 m)
Rotor diameter: (each) 50 ft (15·24 m)
Weight empty: 12,571 lb (5,702 kg)
Weight fully loaded: 21,400 lb (9,707 kg)
Cruising speed: 150 m.p.h. (241 k.p.h.)
max: 158 m.p.h. (254 k.p.h.)
Rate of climb: 1,400 ft/min (427 m/min)
Service ceiling: 14,790 ft (4,508 m)
Range: 268 miles (431 km)
Number of seats: 25

1960 MODEL 114 (CH-47A CHINOOK)

Formerly the YHC-1B, the CH-47A Chinook (which first flew in September 1961) is an enlarged version of the CH-46 and was evaluated under a U.S. Army programme. This medium-sized transport can carry a useful load of the same order as the C-47 Dakota.

The cabin, 30 feet 2 inches (9·2 metres) long, features straight-in rear loading and has an unobstructed cross-section 6½ feet (1·98 metres) high and 7½ feet (2·29 metres) wide. The rear ramp can be operated in flight at speeds of up to 69 m.p.h. (111 k.p.h.). The usable cabin space totals 1,440 cubic feet (almost 41 cubic metres) and the helicopter can carry up to forty-four troops equipped for combat or twenty-four casualties on stretchers together with two medical attendants. An external cargo hook

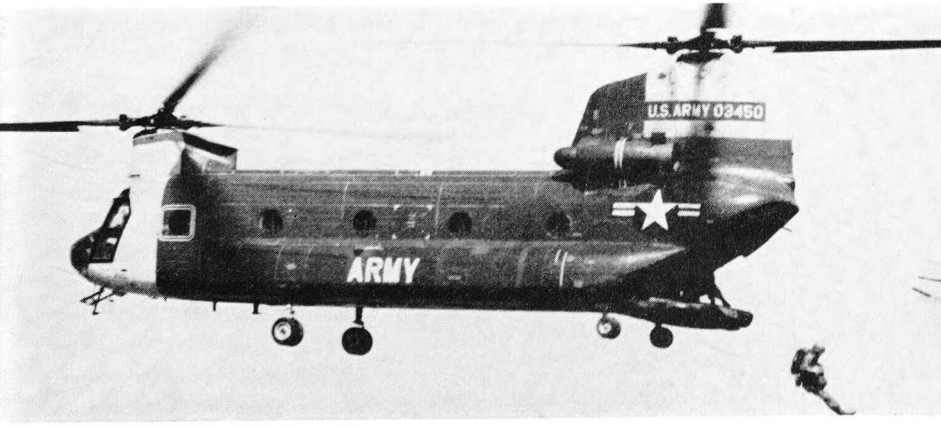
capable of carrying 16,000 pounds (7,257 kilos) in suspension is installed in the cargo hatch.

The engines are placed aft in pods which makes them easily accessible. They were originally 2,200 s.h.p. Lycoming T55-L-5, which were replaced in later models by two more powerful Lycoming T55-L-7 turbines with a continuous rating for each engine of 2,200 s.h.p., a military power rating of 2,500 s.h.p. for thirty minutes and the current maximum rating of 2,650 s.h.p. for ten minutes.

By the end of 1964, more than seventy Chinooks were already in use by the U.S. Army mainly as an all-weather helicopter suited to short-range combat area operations. The Chinook can carry a complete artillery section including two Howitzers, ammunition and gun crews. It can accommodate every component of the U.S. Army's long-range Pershing missile system. An armed and armoured version of the Chinook came out late in 1965. It carries an extensive range of armament as well as armour to protect the crew and vital parts of the helicopter.

By the middle of 1967, more than 300 Chinook CH-47As were delivered to the U.S. Army. From that date onward manufacture turned towards an improved version known as the CH-47B.

Engines (2)*:* Lycoming T55-L-7, 2,650 s.h.p. each
Length: 51 ft (15·54 m)
Width: 12 ft 5 in (3·78 m)
Height: 18 ft 6 in (5·64 m)
Rotor diameter: (each) 59 ft 1 in (18 m)
Weight empty: 17,932 lb (8,134 kg)
Weight fully loaded: 33,000 lb (14,969 kg)
Cruising speed: 109 m.p.h. (175 k.p.h.)



CH-47A

Inclined climb: 1,590 ft/min (485 m/min)
Service ceiling: 9,200 ft (2,804 m)
Range: 115 miles (185 km)
Number of seats: 33

1965 CH-47B

This helicopter is an advanced version of the Chinook with improved flying qualities because of up-rated engines, cambered rotor blades, a blunted aft pylon and strakes along the rear ramp. The CH-47B's maiden flight took place in October 1966. In May 1967 deliveries of it started as a helicopter for the transport of personnel, equipment and logistics. In addition to its service with the U.S. Army, the CH-47B has been purchased for the Royal Air Force in the United Kingdom.

To facilitate conversion, two designations were made simultaneously, CH-47B and CH-47C. The latter is powered with two more powerful turbines, T55-L-11s, each giving a maximum power of 3,750 s.h.p.

Engines (2): Lycoming T55-L-7C, 2,850 s.h.p. each
Weight empty: 19,375 lb (8,788 kg)
Weight fully loaded: 40,000 lb (18,144 kg)
Cruising speed: 177 m.p.h. (285 k.p.h.)
Rate of climb: 1,990 ft/min (607 m/min)
Service ceiling: 16,300 ft (4,968 m)
Range: 350 miles (563 km)
Number of seats: 33

WEILAGE

Arthur Weilage, of Yucaipa, California, has built a light experimental helicopter, whose main object is to be as inexpensive as possible.

1965 WEILAGE BOON

The fuselage is of steel tube, the panels and tail boom in light alloy. The engine, placed horizontally, drives the two-bladed rotor through a multiple vee-belt.

Engine: Lycoming O-235-C, 115 h.p.
Rotor diameter: 22 ft (6·71 m)
Weight empty: 625 lb (283 kg)
Weight fully loaded: 1,000 lb (454 kg)
Speed: 100 m.p.h. (161 k.p.h.)
Number of seats: 2

WIGAL

Since 1958 V. F. Wigal has studied various systems applicable to autogyros. The outcome is a prototype in which an original method is used to set the rotor in motion. Fritz Wigal's unusual autogyro has a tilted engine in the nose. The engine is used to bring the rotor up to the speed required for flying. When that speed is reached, the engine, of drone type, reverts to its normal position.

1963 WIGAL

This experimental model is designed to test a method of bringing the autogyro's rotor into action without recourse to the engine's clutch system. To this end, the two-bladed rotor is topped by a small four-bladed rotor which is made to rotate by blast from the propeller placed in the front of the rotorcraft. This effect is achieved by tilting the engine forward and blocking it. As soon as the rotor system has acquired the speed necessary for flying, the engine is quickly brought back to its normal position and the take-off made.

The Wigal takes off at a speed of 15 m.p.h. (24 k.p.h.) with a take-off run of 100 feet (30·5 metres).

Engine: McCulloch, 72 h.p.
Length: 12 ft (3·66 m)
Rotor diameter: 20 ft (6·1 m)
Weight empty: 320 lb (145 kg)
Weight fully loaded: 570 lb (259 kg)
Cruising speed: 60 m.p.h. (97 k.p.h.)
Landing speed: 15 m.p.h. (24 k.p.h.)
Number of seats: 1

WILFORD

Wilford's first aircraft, built in conjunction with Vincent Burnelli and entered for the Guggenheim Safe Airplane Contest in 1927, was especially designed for low-speed landing.

In 1928 Wilford visited Europe, and while there acquired the patent rights for the United States of a rotary-wing aircraft conceived by a German named Rieseler. In 1929 Wilford began building his own gyroplanes.

The idea behind this American/German partnership was a scheme for feathering the pitch of the blades rotating round the hub instead of the blade-flapping system which La Cierva employed in his autogyros.

Wind-tunnel tests proved the effectiveness of the idea, and the first Wilford gyroplane made successful flights in 1931.

Constant improvements in the rotor enabled the aircraft's original fixed wings to be gradually dispensed with.

In 1937 Wilford built a gyroplane for the United States Navy. It proved very successful, especially when tested by the National Advisory Committee for Aeronautics, but nothing tangible ever materialized.

1931 GYROPLANE

This was the aircraft built for Wilford which applied the ideas of two Germans, Rieseler and Kreiser, and embodied a system for feathering the rotor blades in flight. The feathering control, operated through a system of cams, affected only the lateral parts of the circle described by the rotor.

The original model had an engine of only 85 h.p., but it nevertheless flew with some success when tested at Paoli, Pennsylvania, by F. P. Brown in August 1931.

As a result of these tests, various improvements were later made, such as a much more powerful engine, increase in the size of the rotor, and extension of pitch control to the four quadrants of the circle described by it.

Engine: Jacobs, 165 h.p.
Width: (span) 30 ft (9·14 m)
Height: 10 ft (3·05 m)
Rotor diameter: 30 ft (9·14 m)
Weight fully loaded: 1,800 lb (816 kg)
Number of seats: 1

1937 XOZ-1

This aircraft of the gyroplane type was built by the Pennsylvania Aircraft Syndicate Ltd. It had a four-bladed rotor, the opposite blades of which were restrained at the hub in both the horizontal and vertical planes, and the blades' angle of attack could be controlled during flight.

In horizontal flight the lower wing accounted for some 65 per cent of the total lift.

This aircraft was tested by the National Advisory Committee for Aeronautics.

Engine: Kinner R-5, 155 h.p.
Length: 21 ft 4 in (6·5 m)
Width: (span) 27 ft 4 in (8·33 m)
Height: 10 ft (3·05 m)
Rotor diameter: 32 ft (9·75 m)
Weight empty: 1,455 lb (655 kg)
Weight fully loaded: 1,985 lb (900 kg)
Cruising speed: 90 m.p.h. (145 k.p.h.)
max: 107 m.p.h. (172 k.p.h.)
min: 30 m.p.h. (48 k.p.h.)
Number of seats: 2

1950 MODEL 403 (PROJECT)

Wilford has also had the idea of fitting various types of traditional aircraft with a single-blade rotor. He had particularly in mind an aircraft based on the Bell Airacobra surmounted by a single-bladed rotor of cantilever type fitted with a counterweight. In horizontal flight, the rotor would remain immobile, lying parallel with the fuselage, and when in use would be powered by an auxiliary jet.

Engine: Allison 1,150 h.p. plus turbojet, giving static thrust of 1,250 lb (567 kg)
Rotor radius: 23 ft (7·01 m)
Weight empty: 6,500 lb (2,948 kg)
Weight fully loaded: 9,700 lb (4,400 kg)

Union of Soviet Socialist Republics

Prior to World War I, two names were outstanding in Russia at the start of production of helicopters capable of carrying their pilots: Sikorsky, who later emigrated to the United States of America, and Yuriev, who was the first to develop the modern helicopter configuration with an anti-torque tail rotor. Tatarinov's work did not go beyond minor trials.

It should be observed that in the early years of the twentieth century very advanced studies relating to rotors were made in Russia. Early in 1904 Nikolai Yukovsky released a communication on the 'Useful Load Lifted by a Helicopter' which was later followed by other studies on the same subject from one of his pupils, V. T. Vetchinkin.

ANTONOV

In 1907 K. A. Antonov, who specialized in ballooning, devoted himself to helicopter problems and from 1909 onwards began to study a co-axial aircraft. One was built at St Petersburg (now Leningrad). It consisted of two rotors with multi-blades, each pivoting at the hub and with its tip attached to a large ring, thus enabling the pitch to be varied. The rotors were driven through a gear transmission by a 35 h.p. engine.

The results of the tests made in January 1910 proved disappointing.

ISACCO

Vittorio Isacco (see under Italy) went to Russia in 1932 to build a giant helicopter using the 'helicogyro' configuration embodied in his earlier designs, i.e. a method of propulsion featuring the use of engines driving airscrews and placed on the rotor blades.

Isacco spent three years in the Soviet Union working in collaboration with Izakson on the construction of his six-seater Helicogyro.

1935 HELICOGYRO

This aircraft had a Wright engine situated in the forepart of the fuselage and De Havilland Gipsy engines on the tips of the blades.

Once construction was ended, Isacco had to leave Russia and was thus unable to take part in the actual tests.

Engines (5)*:* 1 Wright 300 h.p. at nose and 4 De Havilland Gipsy III, 120 h.p., at wing tips
Rotor diameter: 90 ft (27·43 m)
Weight fully loaded: 7,000 lb (3,175 kg)
Number of seats: 6

KAMOV

About 1929, Nikolai Ilitch Kamov joined the TsAGI autogyro constructional group where, with Skrjinsky, he built the KASKR I, the first Soviet autogyro, which made successful flights in 1930. A few years later he brought out the A-7 autogyro which soon afterwards was used on liaison work during World War II operations around Smolensk. After the war, Kamov turned his attention towards a helicopter with two co-axial contra-rotating rotors, on which he became a leading Soviet specialist. He also showed interest in convertiplane design.

1947 KA-8

Kamov's initial research into rotors of the co-axial contra-rotating type go back to the immediate post-war period. He then wished to design a small single-seater machine using the minimum mechanical components. The prototype, finished in 1947, consisted of nothing more than a pair of three-bladed rotors driven by a motor-cycle engine, a petrol tank and two flotation bags carrying a rough-and-ready pilot's seat. Even the motor-cycle handlebars were retained. The first engine, an M-76 giving 27 h.p., proved useless. It was boosted up to 45 h.p. which just enabled the vehicle to leave the ground. This prototype was exhibited in public at Tushino in 1948. It took off from the platform of a lorry and rose a few feet into the air.

The experience gained from these various experiments was used to develop the Ka-10.

Engine: M-76, 45 h.p.
Rotor diameter: (each) 18 ft 4½ in (5·6 m)
Weight empty: 403 lb (183 kg)
Weight fully loaded: 606 lb (275 kg)
Number of seats: 1

1949 KA-10

The Ka-10, successor to the Ka-8, resembled the former in configuration and appearance. In the Ka-10 the rotor diameter was slightly greater and the later version also included certain improvements, e.g. in the control system.

The single seat for the pilot was just behind the rotor shaft and had in front of it the fuel tank and the engine. There were two sets of flotation gear.

The first version had a vertical fin aft, which in the Ka-10M was replaced by two elliptical-shaped fins. In addition, the floats were lengthened and given a more pointed shape which enabled the helicopter to manœuvre more rapidly on water.

The Ka-10 and the Ka-10M were both evaluated by the Soviet Armed Forces and in particular by the Navy. Both helicopters were also used for civilian purposes but the use of this '*Vozduchni Motorsikl*'—'flying motor-cycle'—remained somewhat restricted and from 1950 onwards Kamov worked on a bigger, more powerful helicopter.

NATO designation: HAT.
Engine: AI-4G, 55 h.p.
Length: 12 ft 9½ in (3·9 m)
Width: 6 ft 5⅝ in (1·97 m)
Height: 8 ft 2⅜ in (2·5 m)
Rotor diameter: (each) 20 ft 1 in (6·12 m)
Weight fully loaded: 827 lb (375 kg)
Cruising speed: (max.) 72 m.p.h. (116 k.p.h.)
Service ceiling: 8,202 ft (2,500 m)
Range: 84 miles (135 km)
Number of seats: 1

1952 KA-15

This helicopter, with contra-rotating three-bladed rotors, was built during the final development of the Ka-10, and it flew for the first time in 1952. The Ka-15 was originally developed for the Soviet Navy but several variants were produced for civilian use, particularly the Ka-15M. The latter and the Ka-15 were mass-produced. There are also ambulance and agricultural versions of the Ka-15.

The two rotors, with blades made of wood and plastic materials, are powered by a 9-cylinder radial engine cooled by compressed air.

The tailpiece consists of two fins with a steering rudder.

The four-wheeled undercarriage can be replaced by rubber balloons for operations on water.

On 6 May 1959 a Ka-15 piloted by Vsevolod Vinitsky set up a world speed record for helicopters weighing from 1,000 to 1,750 kilos on the Mikhailovakaia-Iljinsky 500-kilometre closed circuit at a speed of 105·909 m.p.h. (170·445 k.p.h.).

NATO designation: HEN.
Engine: AI-14V, 225 h.p.
Rotor diameter: (each) 32 ft 8⅛ in (9·96 m)
Weight unloaded: 2,134 lb (968 kg)

Weight fully loaded: 3,020 lb (1,370 kg)
Cruising speed: (max.) 93 m.p.h. (150 k.p.h.)
Service ceiling: 9,843 ft (3,000 m)
Range: 155 miles (250 km)
Number of seats: 2

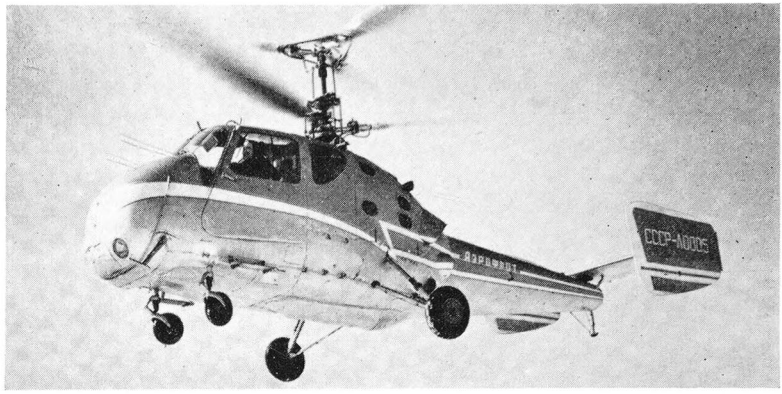
KA-15

1956 KA-18

This development of the Ka-15 has the latter's dynamic components but a cabin re-designed to take four people. It also has a relatively short aircraft-type tail beam on which is mounted a stabilizer and two vertical fins.

The Ka-18 is mass-produced in several different forms: as a passenger transport, for agricultural use and as a helicopter ambulance. In the latter the stretcher is loaded from the front through a small door in the helicopter nose.

NATO designation: HOG.
Engine: AI-14VF, 280 h.p.
Length: 23 ft $0\frac{3}{4}$ in (7·03 m)
Height: 10 ft $11\frac{7}{8}$ in (3·35 m)
Rotor diameter: (each) 32 ft $8\frac{1}{8}$ in (9·96 m)
Weight empty: 2,275 lb (1,032 kg)
Weight fully loaded: 3,219 lb (1,460 kg)
Maximum speed: 93 m.p.h. (150 k.p.h.)
Service ceiling: 11,483 ft (3,500 m)
Range: 250 miles (403 km)
Number of seats: 4



KA-18

1960 KA-20

This helicopter was exhibited in public during the 1961 Tushino Show. It features the contra-rotating rotors common on Kamov helicopters but this model has more room since it is equipped with two small shaft-turbines. Designed essentially for the Soviet Navy, it includes a large radome with radar and supports for missiles on each side of the fuselage.

NATO designation: HARP.

1960 KA-22 VINTOKRYL

This aircraft, exhibited at Tushino in July 1961, somewhat recalls designs by Bratukhin of more than ten years earlier. In appearance this is a convertiplane with two four-bladed rotors (similar to those in various Mil designs) to provide lift, and two propulsion screws. Both rotors and screws are at the tips of a standard wing with wing-tip pods for Ivchenko turboshafts each of 5,700 s.h.p.

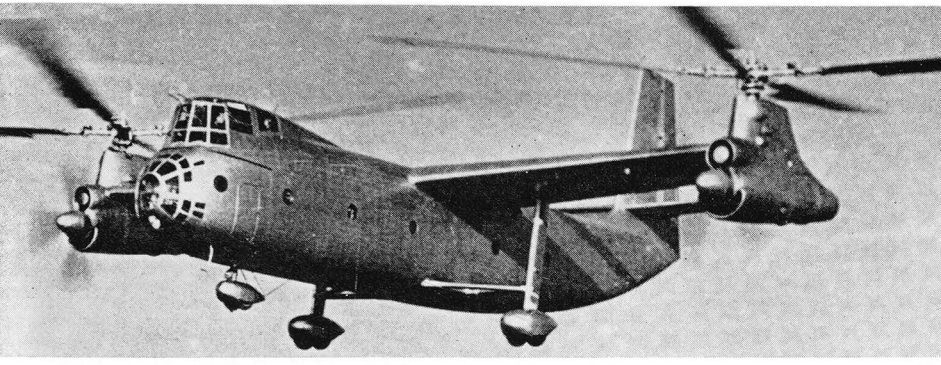
The size of the fuselage is very similar to that of an AN-24 aircraft.

On 7 October 1961 the Ka-22 set up a world speed record over a base of 9·3–15·5 miles (15–25 kilometres) at an average of 221·4 m.p.h. (356·3 k.p.h.); on 24 November 1961 it set up a whole series of world records with a payload going as high as 16·269 long tons (16,485 kilos).

NATO designation: HOOP.

1965 KA-25K

Two turboshaft engines drive this transport helicopter's co-axial three-bladed rotors. The latter can be automatically folded back to the rear. On the left-hand side a door measuring 3 feet $11\frac{1}{4}$ inches × 3 feet $7\frac{1}{4}$ inches (1·2 × 1·1 metres) provides access to the cabin, which can also be used as



KA-22

a cargo hold. Twelve folding seats are placed alongside the cargo compartment. This helicopter has a removable operator's cabin below the nose which enables the operator to observe the cargo while performing erection jobs.

The Ka-25K, which is similar in type to the KA-20, was shown outside Russia for the first time at the Le Bourget Show in June 1967.

Engines (2)*:* Turboshaft
Length: (fuselage) 32 ft 3 in (9·83 m)
Width: 12 ft 4 in (3·76 m)
Height: 17 ft $6\frac{5}{8}$ in (5·35 m)
Rotor diameter: (each) 51 ft 8 in (15·74 m)

KA-25K

Weight empty: 9,260 lb (4,200 kg)
Weight fully loaded: 15,653 lb (7,100 kg)
Cruising speed: 121 m.p.h. (195 k.p.h.)
max: 137 m.p.h. (220 k.p.h.)
Service ceiling: 11,483 ft (3,500 m)
Range: 249 miles (400 km)
Number of seats: 14

1965 KA-26

Intended primarily for agricultural work, the Ka-26 has two engines placed on either side of the upper part of the fuselage and the rotor is similar to that of the Ka-18.

The tailpiece consists of a stabilizer and two fins all fixed on the rear of two tail booms.

The landing gear has four wheels and between the legs of the rear sections attached to the engine housings is placed the freight hold which is removable.

Engines (2)*:* AG-Ivchenko, 325 h.p.
Length: 25 ft 5 in (7.75 m)
Height: 13 ft 6 in (4.12 m)
Rotor diameter: (each) 42 ft $7\frac{3}{4}$ in (13 m)
Payload: 1,433 lb (650 kg)
Cruising speed: 84 m.p.h. (135 k.p.h.)
max: 106 m.p.h. (170 k.p.h.)
Number of seats: 2

KA-26 (CARGO VERSION)

KA-26 (AGRICULTURAL VERSION)

MIL

Mikhail Leontievitch Mil, who had already worked with Kuznetsov on the production of various TsAGI autogyros, in 1947 became one of the principal directors of an experimental station for helicopters. The design developed by him and his team was chosen for quantity production. Since then M. Mil has become the major Soviet specialist for the conventional-type helicopter, with main rotor and anti-torque tail rotor.

1949 MI-1

This Mi-1 helicopter was designed to serve many purposes.

Behind a cabin carrying the pilot and three passengers is the radial 7-cylinder engine driving the rotor through an angle gearbox, from which also runs the shaft driving the 8-foot-2½-inch (2·5-metre) tail rotor on the tail boom.

The main rotor has three fully articulated blades connected through hinges, incorporating friction dampers and with tabs, adjustable from the ground, at their tips.

Widely used since 1951 for rescue work, postal services, etc., this helicopter has also been adopted by the Soviet Air Force and Navy.

It was specially designed to operate under any weather conditions and is particularly suitable for very low-temperature flying; anti-freeze liquid can be continuously sprayed over the windscreen and the blades of both the main and the tail rotors.

In 1954, an ambulance version was produced, which had streamlined housing for stretchers on each side of the fuselage. These were connected by special pipes, which allowed the temperature in the housings to be controlled.

In 1958 various types of float were tried on the Mi-1. Following experiments made during a whaling expedition by the 'Slava' fleet, the version with four inflatable floats was selected.

The Mi-1NKh (*Narodnoye Khozyaistvo*) is a version specially designed for agricultural purposes which can be fitted with two 55-gallon (250-litre) tanks.

The Mi-1, known in NATO circles under the designation HARE, has been made under licence in Poland since 1957. It has set up some 15 FAI records for its category of helicopter.

Engine: AI-26V, 570 h.p.
Length: 39 ft $8\frac{5}{8}$ in (12·11 m)
Height: 10 ft 10 in (3·3 m)
Rotor diameter: 45 ft 11 in (14 m)
Weight empty: 3,924 lb (1,780 kg)
Weight fully loaded: 4,960 lb (2,250 kg)
Cruising speed: (max.) 115 m.p.h. (185 k.p.h.)
Inclined climb: 787 ft/min (240 m/min)
Absolute ceiling: 9,843 ft (3,000 m)
Range: 435 miles (700 km)
Number of seats: 4

1961 Mi-2

This twin-turbine light helicopter belongs to the Mi-1 family. While it is only slightly larger than the latter it has markedly improved speed and payload, approaching those of the Mi-4.

It was quantity-produced in several versions: for passenger transport, as an ambulance and for agricultural use. Its great flexibility enabled it to be used for a wide variety of purposes in all temperatures since it is equipped with de-icing and heating systems.

In May 1963, this helicopter set up a world speed record on a closed 100-kilometre circuit for helicopters weighing from 1,750 to 3,000 kilos at an average speed of 157·715 m.p.h. (253·818 k.p.h.).

NATO designation: HOPLITE.
Engines (2)*:* Izotov, 400 s.h.p. each
Length: 40 ft $0\frac{1}{4}$ in (12·2 m)
Height: 12 ft (3·66 m)
Rotor diameter: 47 ft $6\frac{3}{4}$ in (14·5 m)
Weight empty: 5,137 lb (2,330 kg)
Weight fully loaded: 7,385 lb (3,350 kg)
Maximum speed: 130 m.p.h. (210 k.p.h.)
Service ceiling: 13,123 ft (4,000 m)
Range: 186 miles (300 km)
Number of seats: 8

MI-2

1952 MI-4

The performance of this helicopter is comparable with that of the American Sikorsky S-58.

The four blades of the main rotor are all-metal and each has a small tab adjustable from the ground; the tail rotor is three-bladed.

As in the Sikorsky, the engine is situated forward, and behind a fire-proof partition is the cabin proper, with six port-holes. The quarters for the crew of pilot and wireless operator-navigator include two seats, one on each side of the engine-rotor transmission shaft.

The landing gear consists of four wheels, of which the main ones can be braked and the two front ones are pivotable.

The civil version offers three main types. The transport helicopter has a freight space of 565 cubic feet (16 cubic metres). With an additional petrol tank inside the hold it can cover distances of up to 590 miles (950 kilometres). The Mi-4P can carry ten passengers and 441 pounds (200 kilos) of freight. These helicopters are widely used on short-distance air routes and in areas of difficult access.

An ambulance version can carry eight stretchers.

There is also an agricultural version of the Mi-4 built in 1954, and a military version which can carry fourteen men and all their equipment or else a staff car.

The Mi-4 is used not only in the Soviet Union but also in China, Czechoslovakia, the United Arab Republic, Afghanistan, India, Iran, etc.

A slightly modified version of this helicopter, known to NATO as HOUND, broke various world records during 1956 (see under World Records).

Engine: ACh-82V, 1,430 h.p.
Length: 53 ft 5 in (16·28 m)
Height: 15 ft $3\frac{7}{8}$ in (4·67 m)
Rotor diameter: 68 ft 11 in (21 m)
Weight fully loaded: 15,873 lb (7,200 kg)
Weight empty: 8,488 lb (3,850 kg)
Cruising speed: 106 m.p.h. (170 k.p.h.)
max: 127 m.p.h. (205 k.p.h.)
Absolute ceiling: 11,811 ft (3,600 m)
Range: 249 miles (400 km)
Number of seats: 16

MI-4

1957 MI-6

The Mi-6 is the first Soviet turbine-powered helicopter. It is in fact equipped with two turbines placed above the fuselage to drive a five-bladed rotor through a common reducing gear. The blades are all-metal, and controls for the main rotor are hydraulically actuated. Hydraulically amplified controls regulate the total and cyclic pitch of both the main and the anti-torque tail rotor. The latter has four blades with a diameter of 20 feet 8 inches (6·3 metres).

In appearance this helicopter resembles earlier Mil designs, but its size is infinitely greater. The undercarriage is of the tricycle type with a pivoting front wheel. The main undercarriage legs have two-chamber shock absorbers and a liquid dashpot system to remove the risk of resonance when taxiing.

From the cockpit there is access to the engine cowling panels which are

hydraulically operated and when open are used as maintenance platforms. Thus the engine and the main rotor can be serviced without any ground equipment. Both the rotors and the engine intakes are equipped with a de-icing system.

The spacious cabin can accommodate sixty-five passengers and their baggage or, when used as an ambulance, forty-one stretchers. For carrying freight, the cabin which has a space of about 2,825 cubic feet (80 cubic metres) is provided with clamshell doors and loading ramps for loading or unloading. The maximum acceptable sizes for consignments are: length: 37 feet $8\frac{3}{4}$ inches (11·5 metres); height: 7 feet $6\frac{1}{2}$ inches (2·3 metres); width: 8 feet $6\frac{3}{4}$ inches (2·6 metres).

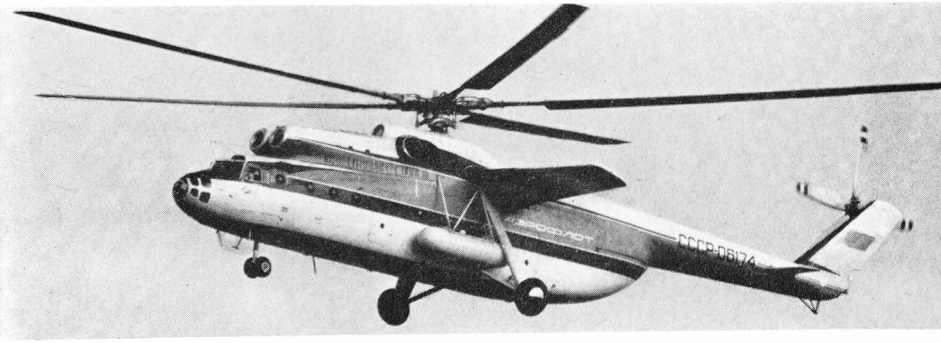
The original design has been altered; the present one includes a stub wing with a span of 50 feet 3 inches (15·3 metres) and a lifting area of 376 square feet (38 square metres). This wing, the angle of incidence of which can be varied, helps to offload the main rotor during high-speed flight.

The Mi-6 holds a certain number of world records. In 1962 at Zakharkov Aerodrome it lifted a payload of 19·68 long tons (20,000 kilos) to a height of 8,983 feet (2,738 metres).

There is also a fire-fighting version of the Mi-6. It has carried out demonstrations in various countries, particularly the South of France, releasing 11·5 tons of water in 15 seconds.

HOOK is the NATO designation of this helicopter.

Engines (2)*:* Soloviev D-25V, 5,500 s.h.p. each
Length: 108 ft (33·18 m)
Height: 32 ft $3\frac{3}{4}$ in (9·85 m)
Rotor diameter: 114 ft 10 in (35 m)
Weight empty: 59,525 lb (27,000 kg)
Weight fully loaded: 85,980 lb (39,000 kg)
Cruising speed: 155 m.p.h. (250 k.p.h.)
max: 186 m.p.h. (300 k.p.h.)



MI-6

Service ceiling: 14,764 ft (4,500 m)
Range: 311 miles (500 km)
Number of seats: 70

1961 MI-8

This helicopter, derived from the Mi-4, retains the latter's general appearance, size and five-bladed rotor. The prototype was powered by only one turbine; the production model has two placed above the cabin which maintain their maximum power up to an altitude of 5,250 feet (1,600 metres).

The fuel tanks are set in bulges on each side of the fuselage which, since the engines are also on the outside, provides greater cabin space than that available in the Mi-4.

The freight version can carry 8,818 pounds (4,000 kilos). Ramps and rear doors allow easy loading and unloading. The internal dimensions of the cabin are: length: 28 feet $10\frac{1}{2}$ inches (8·8 metres); width: 7 feet $6\frac{1}{2}$ inches (2·3 metres); height: 6 feet (1·83 metres).

It can carry a flying crane with a removable winch. Bulky loads can be accommodated within the large cabin with space for up to 812·24 cubic feet (23 cubic metres) of freight.

Both the passenger and the freight versions can be changed into an ambulance with room for twelve stretchers.

The Mi-8's performance was confirmed by a record set up in 1964 over a 2,000-kilometre closed circuit of an average speed of 201·834 k.p.h.

The NATO designation of this helicopter is HIP.

Engines (2)*:* S.P. Isotov TV-2, 1,500 s.h.p. each
Length: (fuselage) 60 ft $3\frac{1}{2}$ in (18·38 m)
Width: 14 ft $9\frac{1}{8}$ in (4·5 m)
Height: 18 ft $4\frac{1}{2}$ in (5·6 m)
Rotor diameter: 69 ft $10\frac{1}{4}$ in (21·29 m)
Weight empty: 16,352 lb (7,417 kg)

MI-8

Weight fully loaded: 24,471 lb (11,100 kg)
Cruising speed: 124 m.p.h. (200 k.p.h.)
max: 143 m.p.h. (230 k.p.h.)
Service ceiling: 14,764 ft (4,500 m)
Range: 280 miles (450 km)
Number of seats: 30

1960 MI-10

The Mi-10 is a flying-crane development of the Mi-6, designed to carry loads of very large size. It has a quadricycle landing gear with a wheel track measuring 19 feet $8\frac{1}{4}$ inches (6 metres), and a protective device measuring 12 feet $3\frac{5}{8}$ inches (3·75 metres) beneath the fuselage. This enables the helicopter to taxi on to the load or to lift it up under the fuselage.

The device is equipped with hydraulic grips controllable from the cockpit or a remote panel. The grips enable loads weighing up to 33,070 pounds (15,000 kilos) to be lifted and attached in only a few moments. The helicopter can also use interchangeable cargo platforms for rapid loading. If the shape of the object to be carried is so complex that the helicopter cannot taxi over it, the Mi-10 can land directly above the object to be carried. The following are the maximum sizes of cargo which can be loaded on to the platforms: length: 65 feet $7\frac{3}{8}$ inches (20 metres); width: 32 feet $9\frac{3}{4}$ inches (10 metres); height: 10 feet 2 inches (3·1 metres).

The helicopter cabin is provided with flap seats for twenty-eight persons; access to the cockpit is through one of the undercarriage legs.

A de-icing system enables this helicopter to be used even in polar regions.

Unlike the Mi-6, the Mi-10 has no wings.

On 23 September 1961 at Zakharkov Aerodrome the Mi-10 set up a world record by carrying a payload of 14·865 long tons (15,103 kilos) to a height of 6,562 feet (2,000 metres).

The Mi-10K is a variant of the Mi-10 with a considerably shorter landing gear. In the forepart under the nose it has a cabin with aft-facing control position for use during loading operations.

The NATO designation of this helicopter is HARKE.

Engines (2)*:* Soloviev D-25V, 5,500 s.h.p. each
Length: (fuselage) 107 ft $9\frac{3}{4}$ in (32·86 m)
Height: 32 ft $5\frac{3}{4}$ in (9·9 m)
Width: 22 ft $8\frac{1}{2}$ in (6·92 m)
Rotor diameter: 114 ft 10 in (35 m)
Weight empty: 59,525 lb (27,000 kg)
Weight fully loaded: 95,791 lb (43,450 kg)
Cruising speed: 112 m.p.h. (180 k.p.h.)
max: 124 m.p.h. (200 k.p.h.)

MI-10

Service ceiling: 9,843 ft (3,000 m)
Range: 155 miles (250 km)
Number of seats: 28

SIKORSKY, 1909

Sikorsky, who was later to become a famous name in the American aeronautical industry, started to build his first helicopter while still a student at the Kiev Polytechnic Institute.

This helicopter, finished in 1909, was 'similar to a large rectangular box'. In the centre of the frame was the transmission box—a large wooden pulley connected by a 4-inch (10·2-centimetre) belt to a similar pulley on the motor. Two concentric vertical tubular shafts were connected with the transmission box. On each side of the shafts there was mounted a two-bladed lifting propeller, the upper one having a diameter of 15 feet (4·57 metres) and the lower 16½ feet (5·03 metres). They rotated in opposite directions at the rate of 160 r.p.m.

Although this helicopter firmly refused to leave the ground, the following year Sikorsky built another on the same principles. The second one also had two contra-rotating co-axial three-bladed rotors 19 feet (5·79 metres) in diameter. Although it partially succeeded in becoming airborne, it was obvious that the rotors were inadequate to lift the weight of a pilot.

After these two attempts Sikorsky devoted himself for a long period to fixed-wing aircraft, and not till 1939 did he revert to the helicopter, in the United States (*q.v.*), where he had settled after World War I.

TATARINOV, 1909

In the very year that Sikorsky was working on his first helicopter, Tatarinov started to build his 'Aeromobile' with a grant provided by the Russian Ministry of War at St Petersburg. The project was never finished, since Sukhomlinov, Russian Minister of War at the time, thought the work was progressing too slowly and consequently funds dried up. In despair, Tatarinov set fire to his rotorcraft and the hangar which housed it.

The Aeromobile had four rotors turning at the end of an X formed of beams. Beneath it the chassis contained an EDTT 25 h.p. water-cooled engine which was to drive the rotors as well as a five-bladed 'centrifugal propeller', which in some respects made this aircraft a convertible. The pilot's seat and controls were placed behind the engine. The total weight was 2,866 pounds (1,300 kilos).

TSAGI

The Central Aero-Hydrodynamic Institute (TsAGI) was set up in Moscow in 1918 with Jukowsky as Director, to investigate and test experimental aircraft in Russia. TsAGI's aircraft are thus all prototypes.

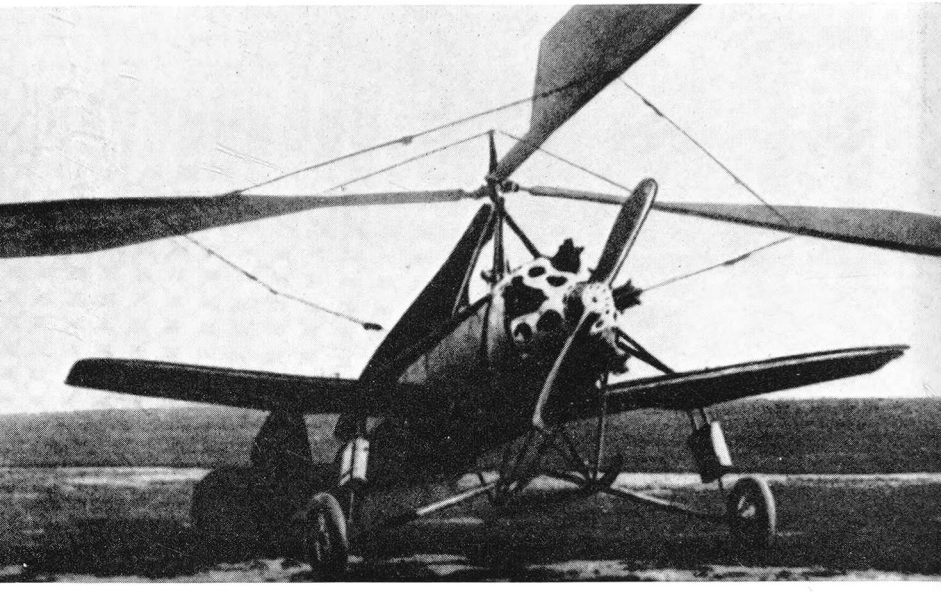
A department to work on rotary wings started its investigations about 1925. It is divided into two sections, one for autogyros, the other for helicopters. Work on autogyros by Kamov, Skrjinsky and Kuznetsov gained considerable impetus about 1928, because by that time Juan de la Cierva's efforts were becoming known far outside his native Spain and his autogyros were successfully flying in the United Kingdom. The first TsAGI autogyro, incidentally, like A. V. Roe's British machines, was built round the fuselage of an Avro 504 fixed-wing aircraft produced under licence in Russia.

Studies of helicopters were made by a research group led by Yuriev assisted by Cheremukhin and Izakson. The first subjects dealt with were rotors fitted with cyclic and collective pitch controls mounted on a test stand. The first production of a full-scale helicopter started about 1930.

1929 KASKR I AND II

This was the first autogyro made in the Soviet Union. Constructed round the fuselage of a U-1, which was a British Avro 504 built under licence, it had one four-bladed rotor and made a few flights at Moscow Aerodrome in 1930.

The KASKR II was the same aircraft with a different power source: the former 100 h.p. engine was replaced by a 230 h.p. engine of the Gnôme-Le Rhône Titan type.



KASKR-11

The two designs got their KASKR designation from abbreviations of the names of the builders Kamov and Skrjinsky.

1931 TSAGI 1-EA

The single-seater helicopter had a four-bladed rotor with cyclic and collective pitch control operated by means of a hanging stick directly connected with the swash plate.

This helicopter had one outstanding feature: one small anti-torque rotor was placed at each end of its crossed metal fuselage and turned in the opposite direction from the other (i.e. they were in contra-rotation).

The 1-EA was tested by Professor Cheremukhin in person and he obtained certain valuable results, though some lack of stability was revealed. After several successful flights, a crash put an end to the trials.

Engine: M-2, 120 h.p.
Rotor diameter: 36 ft $1\frac{1}{8}$ in (11 m)
Weight empty: 2,161 lb (980 kg)
Weight fully loaded: 2,525 lb (1,145 kg)
Number of seats: 1

1931 TSAGI 2-EA

This autogyro was designed by V. A. Kuznetsov, heading a group of

engineers. It had a four-bladed rotor and the engine drove a two-bladed airscrew. The fuselage consisted of welded steel tubes.

The overall external appearance was quite like that of the C-19.

Engine: Gnôme-Le Rhône, 230 h.p.
Cruising speed: min: 34 m.p.h. (55 k.p.h.)
max: 96 m.p.h. (155 k.p.h.)
Absolute ceiling: 13,780 ft (4,200 m)
Range: 105 minutes (endurance)
Number of seats: 2

1933 TSAGI 3-EA

By and large, this helicopter was identical with the TsAGI 1-EA, except that instead of having tricycle landing gear, the rear wheel was replaced by a strut. However, it preserved the two anti-torque contra-rotating rotors fore and aft of its frame.

The 3-EA successfully performed a number of flights, each lasting some ten minutes.

Engine: M-2, 120 h.p.
Number of seats: 1

1933 A-3

This two-seater autogyro, produced by the group under Kuznetsov's leadership, had a three-bladed rotor and a stabilizer equipped with two small fins.

The A-3 was shown to the general public at Moscow during the 1934 Aviation Festival.

Engine: M-11, 115 h.p.
Number of seats: 2

1933 TSAGI A-4

Also designed by Kuznetsov, this was the first autogyro to be built in limited numbers in the U.S.S.R., under the designation of A-4.

The four blades of the rotor were doubly articulated and linked to each other by cables which, at rest, kept them apart. Power from the engine could be transmitted to the rotor by means of a clutch system operated from the pilot's seat, and there was also a brake on the rotor shaft. The reduction ratio between rotor and engine was 1:8·35. These arrangements enabled the autogyro to take off with a run of 115 feet (35 metres) and land on a 20-foot (6-metre) space.

The A-4 had two seats, low wings (the tips of which rose by 35 degrees to improve lateral stability), and a normal rudder for steering.

The landing gear, 8 feet $8\frac{3}{4}$ inches (2·66 metres) in width, was fitted with Sandow-type shock absorbers.

Engine: M-26, giving 300 h.p.

Length: (fuselage) 23 ft 8¼ in (7·22 m)
Height: 13 ft 1½ in (4 m)
Rotor diameter: 42 ft 7¾ in (13 m)
Weight empty: 2,348 lb (1,065 kg)
Weight fully loaded: 3,009 lb (1,365 kg)
Cruising speed: min: 26 m.p.h. (42 k.p.h.)
max: 106 m.p.h. (170 k.p.h.)
Absolute ceiling: 14,764 ft (4,500 m)
Range: 143 miles (230 km)
Number of seats: 2

1933 A-6

With lines generally resembling those of the A-4, the A-6 had wings which could be folded upwards and thus facilitate storing the autogyro in a hangar.

The Red Army used several of these rotorcraft.

1934 A-7

This autogyro designed by Kamov was considerably more streamlined than its predecessors. The rotor had three blades, the fuselage was completely covered by a light-alloy skin and the landing gear was streamlined.

A later version, the A-7-3, which had two small fins below the stabilizer, was used during the last war for some observation missions.

Engine: M-22, giving 480 h.p.
Weight empty: 2,965 lb (1,345 kg)
Weight fully loaded: 4,354 lb (1,975 kg)
Cruising speed: min: 25 m.p.h. (40 k.p.h.)
max: 130 m.p.h. (210 k.p.h.)
Absolute ceiling: 13,123 ft (4,000 m)
Number of seats: 2

1934 A-8

This was a development from Kuznetsov's A-6.
Engine: M-11, 115 h.p.
Cruising speed: min: 25 m.p.h. (40 k.p.h.)
max: 93 m.p.h. (150 k.p.h.)
Absolute ceiling: 9,843 ft (3,000 m)

1934 TSAGI 5-EA (A-9)

Though generally resembling earlier helicopter models, this machine designed by I. P. Bratukhin differed from them in having a six-bladed rotor with three longer and three shorter blades. The pitch-change system had been developed by Yuriev. The two anti-torque rotors fore and aft were preserved from the earlier versions.

Rotor diameter: longer blades: 39 ft 4½ in (12 m)
shorter blades: 25 ft 6¼ in (7·78 m)

1936 A-12

This machine designed by Skrjinsky was the first Soviet wingless autogyro. Its fuselage was that of a Polikarpov fixed-wing aircraft, modified so that the tail was replaced by a stabilizer fitted with two small fins. Thanks to its three-bladed rotor, the A-12 could take off with an 82-foot (25-metre) run, and land on a space of 26 feet (7·9 metres).

The Wright engine drove a two-bladed metal airscrew.

Engine: Wright Cyclone, 670 h.p.
Cruising speed: min: 25 m.p.h. (40 k.p.h.)
max: 186 m.p.h. (300 k.p.h.)
Absolute ceiling: 21,325 ft (6,500 m)

1936 TSAGI 11-EA

This convertible-type aircraft designed by Bratukhin had a six-bladed rotor mounted on a streamlined mast similar to that used on the 5-EA, but the two sets of different-sized blades were larger. The engine, placed in the aircraft's nose, drove both the rotor and the two three-bladed airscrews, one at each end of the two small wings. The fuselage was of the traditional fixed-wing type.

In the PV (standing for *Propulsivnii Variant*) the two airscrews were mounted not on stub wings but on outriggers consisting of a metal lattice.

The two versions TsAGI 11-EA and 11-EA-PV were the aircraft used in the main for the basic developmental work on the Omega.

Engine: Curtiss Conqueror, 600 h.p.
Rotor diameter: longer blades: 50 ft 6¼ in (15·4 m)
shorter blades: 30 ft 2¼ in (9·2 m)

1940 OMEGA

This helicopter, designed by Bratukhin, was of the lateral rotor type with its engines mounted outboard on outriggers, and the two three-bladed rotors were supported by tubular structures.

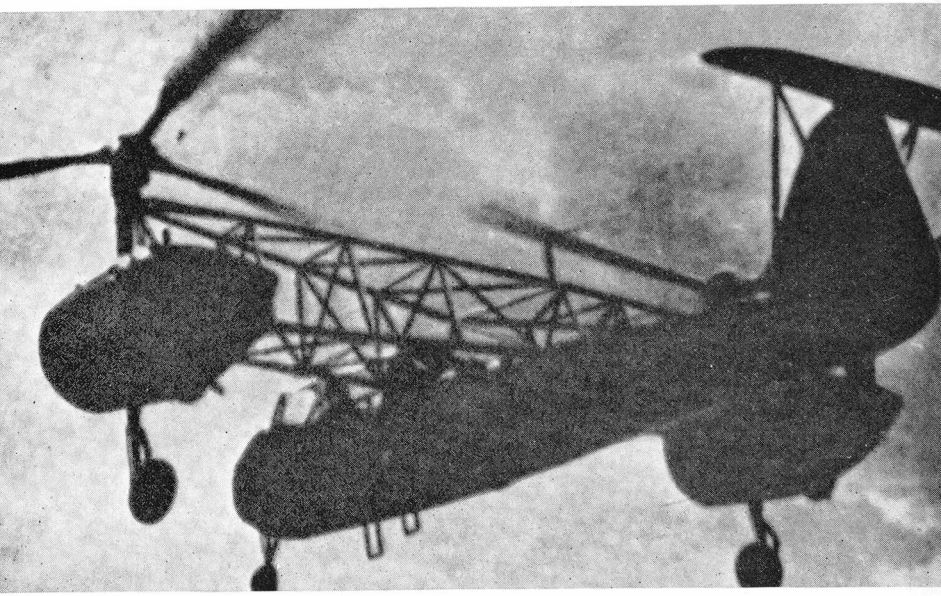
The undercarriage consisted of one wheel on each side of the helicopter fitted to an oleo-pneumatic strut beneath the engine, and of two small wheels, one forward, one aft.

This helicopter was developed under the aegis of OKB 3 (*Opytno Konstruktorskoye Byuro No. 3*, Experimental Design Bureau No. 3). The first prototype, designated 2MG OMEGA and powered by two 220 h.p. air-cooled engines, was used as a test bed for the Omega B. Piloted by K. I. Pomonaref, the latter was publicly shown at Tushino on the 1946 Aviation Day, 18 August.

This helicopter's engines were two 350 h.p. MG-31F.

The same aircraft equipped with Pratt and Whitney engines was designated G-3 and flew from 1945 onwards. The G-4 is a similar helicopter but fitted with two Soviet engines: AI-26GR, driving three-bladed rotors with a larger diameter: 25 feet $3\frac{1}{8}$ inches (7·7 metres).

Engines (2)*:* MG-31F, 350 h.p. each
Rotor diameter (2)*:* 22 ft $11\frac{5}{8}$ in (7 m)
Weight empty: 4,145 lb (1,880 kg)
Weight fully loaded: 5,071 lb (2,300 kg)
Cruising speed: max: 90 m.p.h. (145 k.p.h.)
Service ceiling: 9,843 ft (3,000 m)
Number of seats: 2



OMEGA

1946 OMEGA B-11

This was a development of the Omega. The tubular structure of the outriggers carrying the lateral rotors was replaced by a trapezoid-shaped wing just above the fuselage, through which ran the shafts to synchronize the two engines. These shafts enabled the helicopter to fly on a single engine in the event of breakdown in the other.

The three-bladed rotors were carried on streamlined supports fitted above the engine and the rotor shaft was not upright but tilted slightly forward.

The engines located at the wing tips by means of a reduction drove the shafts driving the rotors, and the shafts for synchronizing the engines as well as the fans were in front of the engines.

The twin-control pilot's seat was fitted with a wide glass window providing good visibility in all directions. Behind the seat was a cabin which could take six passengers.

The first B-5 prototype using the same transmission system and controls as the Omega G-3 was completed in 1947. A second model with cantilever wings was also made in 1947. The latter, the B-9, gave rise to no further developments, nor did model Omega B-10.

The last model in the Omega B series was the B-11, using strut-braced fixed wings similar to those in earlier models. Two prototypes were completed early in 1948 and exhibited in flight at the Tushino Air Festival of the same year. The B-11 was powered by two AI-26 engines boosted to 550 h.p. at take-off.

Engines (2): AI-26GR7, 550 h.p. each
Rotor diameter (2): 32 ft $9\frac{3}{4}$ in (10 m)
Weight empty: 7,474 lb (3,390 kg)
Weight fully loaded: 9,149 lb (4,150 kg)
Cruising speed: 87–96 m.p.h. (140–155 k.p.h.)
Inclined climb: 1,181 ft/min (360 m/min)
Service ceiling: 8,366 ft (2,550 m)
Range: 202 miles (325 km)
Number of seats: 3

VINICHI

In 1957 Vinichi, a test pilot with Mil, designed a small conventional helicopter with a three-bladed rotor. It closely resembles an Mi-1 of

OMEGA B-II

smaller size and with a re-designed nose. The landing gear consists of two skids fitted with wheels behind.

Engine: AI-14, 260 h.p.
Length: 42 ft $3\frac{7}{8}$ in (12·9 m)
Height: 9 ft $5\frac{3}{8}$ in (2·88 m)
Rotor diameter: 36 ft $1\frac{1}{8}$ in (11 m)
Weight empty: 1,786 lb (810 kg)
Weight fully loaded: 2,866 lb (1,300 kg)
Ceiling: 13,780 ft (4,200 m)
Range: 217 miles (350 km)

YAKOVLEV

Alexander Sergeievitch Yakovlev, one of the Soviet Union's best-known aircraft manufacturers, designed the Yak fighters which proved their outstanding operational qualities during World War II. He also designed the first jet fighters used by the Soviet Air Force.

At the end of the war Yakovlev became interested in helicopters and made his start in the rotary-wing field with a contra-rotating-rotor helicopter followed by a conventional helicopter with a single main rotor. He ultimately settled on a tandem configuration of which he became the leading specialist in the Soviet Union.

1945 YAK

Yakovlev's first rotorcraft was a two-seater side-by-side helicopter with a radial engine driving two co-axial contra-rotating two-bladed rotors. Finished in 1947, it failed to give satisfaction during its tests.

Engine: M-11-FR, 140 h.p.
Rotor diameter: 32 ft $9\frac{3}{4}$ in (10 m)
Weight empty: 1,929 lb (875 kg)
Weight fully loaded: 2,249 lb (1,020 kg)
Number of seats: 2

1948 YAK-100

This helicopter was of standard design: a main three-bladed rotor and another also with three blades at the end of the tail boom. It was designed either for training or communication purposes. The prototype was tested during the late 1948–early 1949 period. It was not, however, ready in time for the State Acceptance Trial and was abandoned in favour of the Mi-1 for large-scale production.

Engine: AI-26GRFL, 570 h.p.
Rotor diameter: 47 ft $6\frac{3}{4}$ in (14·5 m)
Weight empty: 3,979 lb (1,805 kg)

Weight fully loaded: 4,806 lb (2,180 kg)
Cruising speed: 84 m.p.h. (135 k.p.h.)
Ceiling: 16,404 ft (5,000 m)
Range: 186 miles (300 km)
Number of seats: 2–3

1952 YAK-24

This helicopter, frequently known in Russia as the 'Flying Truck' and as HORSE in the NATO code, is fitted with two four-bladed rotors in tandem powered by two radial 14-cylinder engines, with a transmission shaft passing through the upper part of the fuselage to synchronize the two rotors. These rotors are of a type similar to those used on the Mi-4.

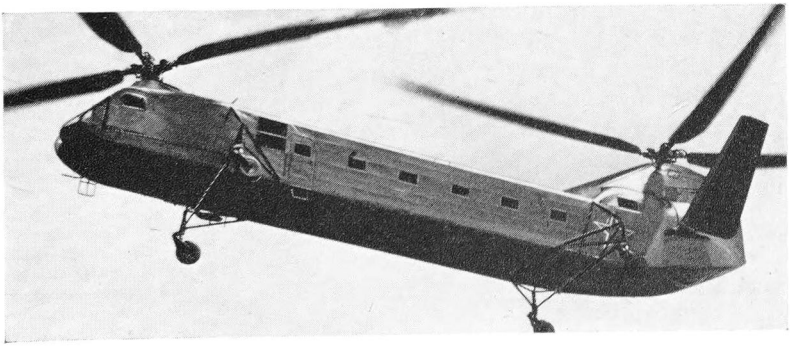
The fuselage itself is roughly square-shaped and consists of a metallic structure, metal-covered fore and aft, fabric-covered in the central section. The nose is completely transparent and provides sufficient space for a crew of two pilots, a wireless operator-navigator and a mechanic.

The main cabin can take thirty-two soldiers with their arms and equipment or else various types of vehicles such as three touring cars or two staff cars. Vehicles can be embarked by a loading ramp, providing access beneath the rear engine housing.

The landing gear consists of four wheels fitted to an oleo-pneumatic shock absorber.

Four of these helicopters were shown to the general public at the Tushino Air Show in July 1955.

Another version with various improvements including an automatic pilot was the departure point for the building in 1960 of the Yak-24A, a helicopter for thirty passengers. There is also a luxury transport version, the Yak-24K. During development the Yak-24 was fitted with various tails ranging from a V-shaped tailpiece to a braced tailplane with a rectangular fin at each tip.



YAK-24

In December 1955, the Yak set up two world records for the greatest load carried to 2,000 metres, and for height reached with a 2,000-kilo payload. It was also a Yak-24 piloted by Y. A. Garnaiev which made the first non-stop helicopter flight from Leningrad to Moscow.

Engines (2)*:* ASH-82, 1,700 h.p. each
Height: 22 ft $11\frac{5}{8}$ in (7 m)
Rotor diameter: (each) 78 ft 9 in (24 m)
Weight empty: 24,251 lb (11,000 kg)
Weight fully loaded: 34,899 lb (15,830 kg)
Cruising speed: 109 m.p.h. (175 k.p.h.)
Ceiling: 14,764 ft (4,500 m)
Range: 158 miles (255 km)

YURIEV

Boris Nikolaevitch Yuriev, who has left his imprint upon a large number of Soviet rotary-wing aircraft, first began to show interest in helicopters as long ago as 1909.

His first project was for a rotorcraft with two-bladed contra-rotating co-axial rotors, the upper with a diameter of 29 feet $6\frac{3}{8}$ inches (9 metres), the lower with a diameter of 9 feet $10\frac{1}{8}$ inches (3 metres). The engine was to be a 70 h.p. rotary Gnôme. Provision was made for a small variable-pitch propeller to ensure directional control.

Another project which followed a few months later was for a helicopter with a present-day configuration: one two-bladed rotor and an anti-torque tail rotor worked by a driving belt.

In 1912 Yuriev found a backer and produced a helicopter along similar lines: one two-bladed rotor (diameter 26 feet 3 inches [8 metres]) driven by an Anzani engine plus an anti-torque tail rotor worked by a cable. This prototype, which had a total weight of 445 lb (202 kilos), was exhibited at the 1912 Moscow International Aeronautical and Automobile Exhibition. Some static tests were made, but the breaking of a rotor shaft forced Yuriev to stop working for lack of funds.

Not until after the 1917 revolution was Yuriev able to take up his work on helicopters again. In 1924 he conceived a helicopter, of which the basic principle was that of the jet-driven rotor aircraft.

To honour his later research work and practical achievements, he was made a member of the U.S.S.R. Academy of Sciences.

F.A.I. List of World Rotorcraft Records

Among the duties of the Fédération Aéronautique Internationale is the confirmation and registration of world records for all types of aircraft. The earliest of these, for distance and speed, goes back to 12 November 1906 and to the Brazilian aeronautical pioneer, Alberto Santos-Dumont, whose aircraft flew 220 metres at an average speed of 41·292 kilometres per hour. By international agreement, only the metric system is used.

No fewer than eighteen years were to pass before the confirmation of the first record for rotorcraft, set up on 14 April 1924 by a Frenchman named Oemichen, who made a straight-line flight of 360 metres in a helicopter designed and built by himself.

The various types of record are as follows:

(1) Distance in a straight line without landing

(2) Distance over a closed circuit

(3) Altitude without payload
Altitude with payload of 1,000 kg
2,000 kg
5,000 kg
10,000 kg
15,000 kg
20,000 kg
25,000 kg

(4) Speed over a straight course of 3 km
15/25 km
Speed over a closed circuit of 100 km
500 km
1,000 km
2,000 km
Speed over a closed circuit of 1,000 km with payload of 1,000 kg
2,000 kg
5,000 kg

(5) Time to climb to 3,000 m
6,000 m
9,000 m

(6) Greatest payload carried to 2,000 m

(7) Endurance: since the end of 1946, records of this type have no longer been listed by the F.A.I.

(8) Women's records

(9) Convertiplane records
(10) Autogyro records

Records are certified in the name and the nationality of the pilot in command of the rotorcraft. Where the crew is composed of several persons, the record is certified in the name and the nationality of the pilot in command of the rotorcraft.

An established record is regarded as having been beaten only if the new one exceeds it by not less than 1 per cent.

(1) DISTANCE IN A STRAIGHT LINE WITHOUT LANDING

Date	*Distance*	*Pilot*	*Rotorcraft*
14. 4.1924	360 m	Oemichen (France)	Oemichen
17. 4.1924	525 m	Oemichen (France)	Oemichen
18. 4.1924	736 m	Pescara (France)*	Pescara 2
10.10.1930	1·078 km	Marinello Nelli (Italy)	D'Ascanio
26. 6.1937	16·400 km	Ewald Rohfls (Germany)	Focke 61
25.10.1937	108·974 km	Hanna Reitsch (Germany)	Focke 61
20. 6.1938	230·348 km	Karl Bode (Germany)	Focke 61
22. 5.1946	1,132·337 km	Major F. T. Cashman (U.S.A.)	Sikorsky R-5
17. 9.1952	1,958·796 km	Elton J. Smith (U.S.A.)	Bell 47D-1
27. 9.1964	2,170·70 km	M. Antoniou (U.S.A.)	Bell UH-1D
6–7.3.1965	3,388·7 km	J. R. Williford (U.S.A.)	Sikorsky SH-3A
6–7.4.1966	3,561·55 km	R. G. Perry (U.S.A.)	Hughes OH-6A

(2) DISTANCE OVER A CLOSED CIRCUIT

Date	*Distance*	*Pilot*	*Rotorcraft*
14.12.1935	500 m	Maurice Claisse (France)	Bréguet Gyroplane
24.11.1936	44 km	Maurice Claisse (France)	Bréguet Gyroplane
26. 6.1937	80·604 km	Ewald Rohfls (Germany)	Focke 61
14.11.1946	1,000 km	Major Jensen & Major Dodds (U.S.A.)	Sikorsky R-5A
2. 7.1953	1,252·572 km	Jean Boulet (France)	SE-3120
11. 8.1956	1,929·732 km	Lieutenant-Colonel Bush & Major W. Dysinger (U.S.A.)	H-21C Vertol

*At that time records were registered in the name of the country where they were established.

Date	*Distance*	*Pilot*	*Rotorcraft*
19. 4.1964	2,465·736 km	Vasily Kolochenko (U.S.S.R.)	Mi-8
18. 9.1964	2,600·189 km	J. A. Johnston (U.S.A.)	Bell UH-1D
26. 3.1966	2,800·200 km	J. Schweidel (U.S.A.)	Hughes OH-6A

(3) ALTITUDE

Date	*Altitude*	*Pilot*	*Rotorcraft*
Without payload			
13.10.1930	18 m	Marinello Nelli (Italy)	D'Ascanio
26. 9.1936	158 m	Maurice Claisse (France)	Bréguet Gyroplane
25. 6.1937	2,439 m	Ewald Rohfls (Germany)	Focke 61
29. 1.1939	3,427 m	Karl Bode (Germany)	Focke 61
10. 2.1947	5,842 m	Major E. M. Cassell (U.S.A.)	Sikorsky R-5
21. 3.1949	6,468 m	Captain H. D. Gaddis (U.S.A.)	Sikorsky S-52
2. 9.1953	6,739 m	Captain R. M. Dobyns (U.S.A.)	Piasecki YH-21
17.10.1954	7,474 m	Billy Wester (U.S.A.)	Sikorsky XH-39
6. 6.1955	8,209 m	Jean Boulet (France)	SE-3130
28.12.1957	9,076 m	J. E. Bowman (U.S.A.)	Cessna YH-41
13. 6.1958	10,984 m	Jean Boulet (France)	SE-3150
With payload of 1,000 kg			
26. 4.1956	6,048 m	Vsevolod Vinizky (U.S.S.R.)	Mi-4
26. 3.1960	7,465 m	G. Alfierov (U.S.S.R.)	Mi-4
25. 5.1961	8,037·27 m	W. C. McMeen (U.S.A.)	Kaman H-43B
24. 4.1965	8,943 m	T. J. Clark (U.S.A.)	Sikorsky CH-54A
With payload of 2,000 kg			
17.12.1955	5,082 m	G. Tinjakov & E. Milutichev (U.S.S.R.)	Flying Truck, 2 rotors
25. 4.1956	6,018 m	Rafail Kapréljan (U.S.S.R.)	Mi-4
12. 3.1965	6,369 m	Tchernobrovkin (U.S.S.R.)	Mi-4

Date	*Altitude*	*Pilot*	*Rotorcraft*
With payload of 2,000 kg			
24. 4.1965	8,761 m	U. V. Brown (U.S.A.)	Sikorsky CH-54A
With payload of 5,000 kg			
9.11.1956	3,722 m	Anderson & Decker (U.S.A.)	Sikorsky HR2S
16. 4.1959	5,584 m	S. Brostev (U.S.S.R.)	Mi-6
24. 4.1965	6,514 m	T. J. Clark (U.S.A.)	Sikorsky CH-54A
26. 5.1965	7,151 m	V. Kolochenko (U.S.S.R.)	Mi-10K
With payload of 10,000 kg			
30.10.1957	2,432 m	R. Kapréljan (U.S.S.R.)	Mi-6
16. 4.1959	4,885 m	R. Kapréljan (U.S.S.R.)	Mi-6
With payload of 15,000 kg			
23. 9.1961	2,326 m	Alfierov (U.S.S.R.)	Flying crane (Mi-10)
12. 9.1962	2,738 m	R. Kapréljan (U.S.S.R.)	Mi-6
28. 5.1965	2,840 m	Alfierov (U.S.S.R.)	Mi-10K
With payload of 20,000 kg			
13. 9.1962	2,738 m	R. Kapréljan (U.S.S.R.)	Mi-6
28. 5.1965	2,840 m	Alfierov (U.S.S.R.)	Mi-10K
With payload of 25,000 kg			
28. 5.1965	2,840 m	Alfierov (U.S.S.R.)	Mi-10K

(4*a*) SPEED OVER A STRAIGHT COURSE

Date	*Speed*	*Pilot*	*Rotorcraft*
3 km			
28. 6.1948	200·065 k.p.h.	B. H. Arkell (Great Britain)	Fairey Gyrodyne
27. 4.1949	208·494 k.p.h.	H. E. Thompson (U.S.A.)	Sikorsky S-52
4. 9.1953	236·193 k.p.h.	R. M. Dobyns (U.S.A.)	Piasecki YH-21
26. 8.1954	251·067 k.p.h.	Billy Wester (U.S.A.)	Sikorsky S-59
11.11.1956	261·91 k.p.h.	Anderson & Decker (U.S.A.)	Sikorsky HR2S
30.12.1961	320 k.p.h.	P. L. Sullivan (U.S.A.)	Sikorsky HSS-2

Date	*Speed*	*Pilot*	*Rotorcraft*
3 km			
19. 8.1963	341·23 k.p.h.	J. Boulet & Coffignot (France)	Super Frelon
20 km			
24.11.1936	44·692 k.p.h.	Maurice Claisse (France)	Bréguet
26. 6.1937	122·553 k.p.h.	Ewald Rohfls (Germany)	Focke 61
3. 6.1946	178·394 k.p.h.	Lieutenant-Colonel K. S. Wilson (U.S.A.)	Sikorsky R-5
15/25 km			
21. 9.1961	320 k.p.h.	N. Liochine, Kolschenko & Novikov (U.S.S.R.)	Mi-6
5. 2.1962	339 k.p.h.	R. Crafton (U.S.A.)	Sikorsky HSS-2
23. 7.1963	350·47 k.p.h.	Boulet & Coffignot (France)	Super Frelon

(4*b*) SPEED OVER A CLOSED CIRCUIT (UNLOADED)

Date	*Speed*	*Pilot*	*Rotorcraft*
100 km			
6. 5.1949	197·545 k.p.h.	H. E. Thompson (U.S.A.)	Sikorsky S-52
12. 7.1956	228·39 k.p.h.	C. E. Hargett & E. D. Hill (U.S.A.)	Sikorsky H-34
21.11.1959	268·92 k.p.h.	B. Zemskov & N. Liochine (U.S.S.R.)	Mi-6
24. 5.1961	281·47 k.p.h.	P. L. Sullivan (U.S.A.)	Sikorsky HSS-2
1.12.1961	294·188 k.p.h.	B. K. Lloyd (U.S.A.)	Sikorsky HSS-2
23. 7.1963	334·28 k.p.h.	Boulet & Coffignot (France)	Super Frelon
26. 8.1964	340·15 k.p.h.	Galitsky & Vlasov (U.S.S.R.)	Mi-6
500 km			
2. 7.1953	107·193 k.p.h.	Jean Boulet (France)	SE-3120
29. 4.1956	187·254 k.p.h.	B. Zemskov & R. Kapréljan (U.S.S.R.)	Mi-4
12. 7.1956	218·893 k.p.h.	C. E. Hargett & E. D. Hill (U.S.A.)	Sikorsky H-34
26. 7.1960	238·906 k.p.h.	J. L. Marinelli (U.S.A.)	Bell UH-1
1.12.1961	288·877 k.p.h.	B. K. Lloyd (U.S.A.)	Sikorsky HSS-2

Date	*Speed*	*Pilot*	*Rotorcraft*
500 km			
15. 9.1962	315·657 k.p.h.	B. Galitski & Kozyarev (U.S.S.R.)	Mi-6
1,000 km			
14.11.1946	107·251 k.p.h.	Major D. H. Jensen (U.S.A.)	Sikorsky R-5A
12. 7.1956	213·453 k.p.h.	C. E. Hargett & E. D. Hill (U.S.A.)	Sikorsky H-34
1.12.1961	282·118 k.p.h.	B. K. Lloyd (U.S.A.)	Sikorsky HSS-2
15. 9.1962	300·377 k.p.h.	Galitski & Kozyarev (U.S.S.R.)	Mi-6
2,000 km			
19. 4.1964	201·834 k.p.h.	V. Kolochenko (U.S.S.R.)	Mi-6
23. 9.1964	215·626 k.p.h.	J. C. Watts (U.S.A.)	Bell UH-1D
20. 3.1966	227·742 k.p.h.	D. Sczczepanski (U.S.A.)	Hughes OH-6A

(4*c*) SPEED OVER A CLOSED CIRCUIT OF 1,000 KM (LOADED)

Date	*Speed*	*Pilot*	*Rotorcraft*
With payload of 1,000 kg			
11. 9.1962	284·373 k.p.h.	V. Kolochenko (U.S.S.R.)	Mi-6
15. 9.1962	300·377 k.p.h.	B. Galitski, F. Kozarev, M. Kharitonov, K. Matinov, Y. Kokcheev & S. Rybalko (U.S.S.R.)	Mi-6
With payload of 2,000 kg			
11. 9.1962	284·354 k.p.h.	V. Kolochenko, G. Karapetian, S. Ivanov, S. Kliepetov & V. Shcherbinine (U.S.S.R.)	Mi-6
15. 9.1962	300·377 k.p.h.	B. Galitski, F. Kozarev, M. Kharitonov, K. Matinov, Y. Kokcheev & S. Rybalko (U.S.S.R.)	Mi-6
With payload of 5,000 kg			
11 9.1962	284·354 k.p.h.	V. Kolochenko, G. Karapetian, S. Ivanov, S. Kliepetov & V. Shcherbinine (U.S.S.R.)	Mi-6

(5) TIME TO CLIMB TO GIVEN ALTITUDE

Date	*Time*	*Pilot*	*Rotorcraft*
3,000 m			
5. 9.1957	7 min 48 sec	R. Witowsky (Poland)	SM-1
11. 9.1957	6 min 45·6 sec	S. Gajewski (Poland)	SM-1
13. 6.1958	5 min 30·6 sec	J. Boulet (France)	SE-3150
19. 7.1960	3 min 29·1 sec	G. J. Boyle (U.S.A.)	Bell HU-1
24.10.1961	2 min 41·5 sec	F. M. Carney (U.S.A.)	Kaman H-43B
14. 4.1962	2 min 17·3 sec	L. F. Wilhelm (U.S.A.)	Bell YHUH-1D
7.10.1964	2 min 9·65 sec	E. E. Nelson (U.S.A.)	Bell UH-1D
6,000 m			
13. 6.1958	11 min 0·1 sec	J. Boulet (France)	SE-3150
19. 7.1960	8 min 7·1 sec	G. J. Boyle (U.S.A.)	Bell HU-1
24.10.1961	6 min 49·3 sec	F. M. Carney (U.S.A.)	Kaman H-43B
13. 4.1962	5 min 47·4 sec	B. B. Buckner (U.S.A.)	Bell YHUH-1D
7.10.1964	4 min 35·75 sec	E. E. Nelson	Bell UH-1D
9,000 m			
13. 6.1958	17 min 48·9 sec	J. Boulet (France)	SE-3150
24.10.1961	14 min 30·7 sec	F. M. Carney (U.S.A.)	Kaman H-43B
7.10.1964	9 min 13·7 sec	W. L. Welter (U.S.A.)	Bell UH-1D

(6) GREATEST LOAD CARRIED TO 2,000 M

Date	*Load*	*Pilot*	*Rotorcraft*
17.12.1955	4,000 kg	E. Milutichev & G. Tinyakov (U.S.S.R.)	Flying Truck, 2 rotors
10.11.1956	6,010 kg	Anderson & Decker (U.S.A.)	HR2S-1
30.10.1957	12,004 kg	R. Kapréljan, Alferov & Novikov (U.S.S.R.)	Mi-6
23. 9.1961	15,103 kg	B. Alfierov, Zemskov & Bartchenkov (U.S.S.R.)	Flying crane (Mi-10)
13. 9.1962	20,117 kg	R. Kapréljan & Liochine (U.S.S.R.)	Mi-6

(7) ENDURANCE

Since the end of 1946, records of this kind have no longer been listed by the F.A.I., but a few earlier ones may have some historical interest.

Date	*Time*	*Pilot*	*Rotorcraft*
8.10.1930	8 min 45·2 sec	Marinello Nelli (Italy)	D'Ascanio helicopter
24.11.1936	1 hr 2 min 5 sec	Maurice Claisse (France)	Bréguet Gyroplane
25. 6.1937	1 hr 20 min 49 sec	Ewald Rohfls (Germany)	Focke 61
14.11.1946	9 hr 57 min	Jensen & Dodds (U.S.A.)	Sikorsky R-5

(8) WOMEN'S RECORDS

Date		*Pilot*	*Rotorcraft*
Distance in a straight line without landing			
25.10.1937	108·974 km	Hanna Reitsch (Germany)	FW-61-VID
25. 6.1960	547·671 km	Anna Gueppennere (U.S.S.R.)	Mi-1
10. 2.1961	653·12 km	Dora J. Dougherty (U.S.A.)	Bell 47G-3
2. 8.1965	1,040 km	T. Roussian (U.S.S.R.)	Mi-4
3. 9.1965	1,239·199 km	T. Larina (U.S.S.R.)	Mi-1
Distance over a closed circuit			
18. 6.1960	503·298 km	T. Roussian (U.S.S.R.)	Mi-1
18. 9.1963	794·817 km	T. Roussian (U.S.S.R.)	Mi-1
2. 9.1966	1,004 km	T. Larina (U.S.S.R.)	Mi-1
14. 9.1967	2,082·224 km	I. Kopets (U.S.S.R.)	Mi-8
Altitude			
27. 3.1959	4,140 m	T. Roussian (U.S.S.R.)	Mi-1
8. 2.1961	5,908·86 m	Dora J. Dougherty (U.S.A.)	Bell 47G-3
12. 1.1965	7,524 m	T. Roussian (U.S.S.R.)	Mi-4
Speed over a closed circuit of 100 km.			
28. 3.1958	175·459 k.p.h.	Irina Gourova (U.S.S.R.)	Mi-1
22. 6.1961	196·688 k.p.h.	Anna Gueppenere (U.S.S.R.)	Mi-1
10. 6.1965	269·38 k.p.h.	T. Roussian (U.S.S.R.)	Mi-2
Speed over a closed circuit of 500 km.			
18. 6.1960	142·642 k.p.h.	T. Roussian (U.S.S.R.)	Mi-1
21. 7.1965	195·447 k.p.h.	S. Kotova & T. Fomitcheva (U.S.S.R.)	Mi-4
23. 8.1967	273·507 k.p.h.	I. Kopets (U.S.S.R.)	Mi-8

Date		*Pilot*	*Rotorcraft*
Speed over a closed circuit of 1,000 *km*			
2. 9.1966	137·38 k.p.h.	T. Larina (U.S.S.R.)	Mi-1
28. 8.1967	258·266 k.p.h.	L. Issavea (U.S.S.R.)	Mi-8
Speed over a closed circuit of 2,000 *km*			
14. 9.1967	235·119 k.p.h.	I. Kopets (U.S.S.R.)	Mi-8

(9) CONVERTIPLANE RECORDS

Date		*Pilot*	*Rotorcraft*
Altitude			
24.11.1961	2,588 m	D. Efremov & G. Gromov (U.S.S.R.)	Kamov Vintokryl
Altitude with payload of 15,000 kg			
24.11.1961	2,588 m	D. Efremov & G. Gromov (U.S.S.R.)	Kamov Vintokryl
Speed over a straight course of 15/25 km			
7.10.1961	356·3 k.p.h.	D. Efremov & G. Gromov (U.S.S.R.)	Kamov Vintokryl
Speed over a closed circuit of 100 km			
5. 1.1959	307·22 k.p.h.	W. R. Gellatly & J. G. P. Morton (New Zealand)	Fairey Rotodyne
Greatest load carried to 2,000 m			
24.11.1961	16,485 kg	D. Efremov & G. Gromov (U.S.S.R.)	Kamov Vintokryl

(10) AUTOGYRO RECORDS

Date		*Pilot*	*Autogyro*
Distance in a straight line without landing			
15. 5.1967	133·20 km	I. Bensen (U.S.A.)	B-8M
Distance over a closed circuit			
15. 5.1967	119·58 km	I. Bensen (U.S.A.)	B-8M
Altitude			
15. 5.1967	2,217 m	I. Bensen (U.S.A.)	B-8M
11. 5.1968	4,639 m	K. Wallis (U.K.)	WA-116
Speed over a straight course of 3 km			
15. 6.1967	117·97 k.p.h.	I. Bensen (U.S.A.)	B-8M
Speed over a straight course of 15/25 km			
15. 6.1967	127·15 k.p.h.	I. Bensen (U.S.A.)	B-8M
Speed over a closed circuit of 100 km			
15. 5.1967	82·64 k.p.h.	I. Bensen (U.S.A.)	B-8M

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